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SUMMARY AND ANALYSIS OF PERFORMANCE AND STABILITY CHARACTERISTICS OF THE REFAN JT8D-109 ENGINE

UNITED TECHNOLOGIES CORPORATION
Pratt & Whitney Aircraft Division

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16. Abstract

The objective of the JT8D refan program was to design, fabricate and test certifiable modifications of the JT8D engine which would reduce the noise generated by JT8D-powered aircraft. This was to be accomplished while retaining the reliability and maintainability of the JT8D engine.

This report documents the refan JT8D-109 performance and stability characteristics as determined from sea level testing at P&WA, altitude testing at NASA LeRC, and DC-9 flight testing at McDonnell-Douglas. The test results are summarized as follows.

- TSFC at SLS achieved design goal of 12.66% reduction
- TSFC at altitude average cruise power 0.5% higher than design goal
- TSFC at altitude maximum cruise power 1.7–3.7% higher than design goal
- Ground starting consistent with JT8D-9 base engine
- Successful flight starts without starter assist
- Transient surge margin equivalent to JT8D-9
- Stable engine operation with inlet distortion
- Stable engine operation during snap acceleration and deceleration
- Flight idle setting required for acceptable aborted-landing go-around acceleration time due to increase in low-rotor moment of inertia
- A performance improvement program should be conducted as part of any future certification program.

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I. SUMMARY

The objective of the JT8D refan program was to design, fabricate and test a certifiable modification of the JT8D engine which would reduce the noise generated by JT8D-powered aircraft. This noise reduction objective was to be accomplished while retaining the reliability and maintainability of the JT8D engine and the performance of the current JT8D-powered aircraft, at minimum retrofit cost.

The refan program was conducted by Pratt & Whitney Aircraft under NASA Contracts NAS3-16808 and NAS3-17840. The program was divided into two phases: Phase I, Contract NAS3-16808, which covered the preliminary definition and design of the refan engine modifications, and Phase II, Contract NAS3-17840, which covered the installation design effort and the development testing of the engine modifications. The development testing was to ensure the structural integrity of the engine modifications and to determine whether the program objective of engine noise reduction had been achieved, while maintaining or improving the engine stability and performance.

This report documents the JT8D-109 stability and performance characteristics as required under Task VI of the Phase II contract. These characteristics were determined from the following test programs:

- Sea level development testing at P&WA
- Altitude testing at the NASA LeRC
- DC-9 flight testing at McDonnell-Douglas

The principal test results are summarized below:

<u>Performance Characteristics</u>

- Sea level static testing of the JT8D-109 refan engine showed a thrust specific fuel consumption decrease of 12.76%, as compared to the base JT8D-9 configuration, which is within the design goal of 12.66%.
- The thrust specific fuel consumption at altitude average cruise power was 0.5% higher than the design goal.
- The thrust specific fuel consumption at altitude maximum cruise power was higher than design goals by 1.7-3.7%, due primarily to higher than anticipated fan duct pressure losses and slightly lower than predicted exhaust nozzle performance.

- A performance improvement program should be conducted as part of any future program to certify the JT8D-109 engine model.

Stability Characteristics

- The JT8D-109 ground starting characteristics were consistent with typical JT8D-9 base engine experience.
- Successful flight starts were demonstrated without starter assist within the current JT8D-powered aircraft flight start envelope.
- The transient surge margin in the off-idle region was equivalent to that of the JT8D-9 base engine.
- Stable engine operation was demonstrated with inlet distortion screens installed to simulate flight conditions.
- Stable engine operation was demonstrated during both cold and hot engine snap accelerations from both minimum and flight idle throughout the DC-9/727 flight envelope.
- Stable engine operation was demonstrated during deceleration transients during sea level and DC-9 flight testing. Testing conducted at the NASA LeRC altitude test facility indicated pressure fluctuations at altitudes above 15,000 feet, which may have been caused by low-pressure compressor surge and surge bleed valve cycling or may have been induced by the test facility.
- The JT8D-109 engine accelerated 2.9 seconds slower than the base JT8D-9 engine, due primarily to a 40% increase in low-rotor inertia. A flight idle setting was required to provide acceptable aborted-landing go-around acceleration capability.

II. INTRODUCTION

The JT8D turbofan engine is widely used by the air transport industry to power short- and medium-range commercial aircraft. Since these aircraft comprise a significant part of the domestic airline fleet, a reduction in their noise level would have a favorable effect on the airport community noise environment. Thus, the JT8D-100 series engines were designed as low-noise, retrofit configurations obtainable from any of the current JT8D engine models. The fundamental design concept of the JT8D refan program was to provide a higher-bypass-ratio engine to reduce the jet exhaust velocity and, thereby, the jet noise. Fan and compressor noise levels were minimized by the strict application of acoustic design principles and designed-in noise reduction features.

The modified engine cycle, selected during Phase I, Contract NAS3-16808, of the refan program, was based upon an increased-diameter, single-stage fan and two additional core engine compressor stages, which replace the existing two-stage fan. Modifications were also made to the low-pressure turbine to provide the increased torque required by the larger-diameter fan.

The resultant JT8D-100 engine models have the following characteristics at takeoff thrust, compared to the current JT8D engine; (1) the total airflow and the bypass ratio are increased, and (2) the fan pressure ratio and the engine speed are reduced. The resultant engine is also longer, larger in diameter, and heavier than the JT8D base model, but these latter changes are compensated by the increased thrust and decreased fuel consumption of the modified engine, thus providing the capability for maintaining the performance of the current JT8D-powered aircraft.

Phase II of the JT8D refan program, Contract NAS3-17840, was comprised of (1) completion of the Phase I mechanical design effort and (2) evaluation of the JT8D-100 component designs through additional design analysis and rig and engine testing. The data presented in this report are for the JT8D-109 engine, the JT8D-100 series refan derivative of the production JT8D-9 engine. The report documents the JT8D-109 performance and stability characteristics as required under Task VI of the Phase II contract. In compliance with this task, a system development program was conducted by Pratt & Whitney Aircraft on three experimental engines and a fan/low-pressure compressor rig to verify that the refan modifications maintained or improved the engine stability and performance. The results of engine acoustic tests to evaluate the effectiveness of the refan engine to reduce noise are summarized in ref. (CR-134875).

Two of the engines were obtained from the P&WA JT8D experimental engine program and were designated Experimental Engine Number 1 (EE-1) and Experimental Engine Number 2 (EE-2). These engines were updated to JT8D-9 specifications and calibrated to establish their base performance levels and transient performance characteristics prior to their conversion to the JT8D-109 configuration. Subsequent to the conversions, a systems development program was conducted which included the following programs:

- Sea level performance calibrations
- Two 1000-cycle low-cycle fatigue tests
- 150-hour FAA-type endurance test
- Stress measurements on the unique JT8D-100 parts
- Stability tests with inlet distortion
- Low-pressure and high-pressure compressor sea level static surge margin tests
- Douglas DC-9 inlet and exhaust system engine matching and compatibility tests
- Acoustic evaluation of the fully treated JT8D-109 engine with the P&WA reference hardware (hardwall) and with treated inlet and exhaust hardware designed to simulate the DC-9 flight inlet and exhaust systems.

The third engine utilized in the experimental engine program, designated Experimental Engine Number 3 (EE-3), was acquired from Pratt and Whitney Aircraft Sales as a JT8D-9 zero time production engine. The engine was tested as a JT8D-9 engine to establish base levels of steady-state and transient performance prior to conversion to the JT8D-109 configuration. Subsequent to this conversion, steady state and transient performance testing was conducted to determine JT8D-109 characteristics. Following this testing, a systems development program was conducted at the NASA Lewis Research Center (NASA-LeRC) in Cleveland, Ohio. The following programs were conducted:

- Engine transient performance characteristics with and without inlet distortion at altitude conditions
- Determination of altitude starting envelope
- Altitude steady state performance calibrations

A fan/low-pressure compressor (LPC) test unit, consisting of a full-scale fan/LPC section of the JT8D-109 engine, was assembled into a rig configuration. The following tests were conducted:

- Stress measurements on selected disks, blades and stators
- Uniform inlet flow performance for various fan and LPC operating lines
- Distorted inlet flow for various fan and LPC operating lines

In addition to the three refan experimental engines, three production engines provided by the airframe manufacturers were converted; two to JT8D-109 models for DC-9 flight testing by McDonnell-Douglas and one to the JT8D-115 model for ground testing by the Boeing Company.

The performance characteristics presented in this report primarily utilize the data obtained from the production quality engine, EE-3, in both the JT8D-9 and the refan JT8D-109 configurations. Additional information from the DC-9 flight test program and from the sea level testing of engines EE-1 and EE-2 is presented as required.

The stability characteristics presented in this report are based on test results obtained from sea level testing at Pratt & Whitney Aircraft, altitude testing at NASA LeRC, and DC-9 flight testing conducted by McDonnell-Douglas Corporation.

III. JT8D-109 ENGINE CYCLE AND DESIGN

A. ENGINE CYCLE

The JT8D engine is a relatively low-bypass fan engine with a relatively high primary jet velocity. Means for attenuating fan-generated engine noise using nacelle treatment have been developed, but no practical method for reducing the noise generated by the interaction of the primary jet stream with the ambient air, by means external to the engine, has been developed. For the JT8D engine, jet noise is predominant at takeoff power, and also at lower power conditions when fan duct acoustic treatment is incorporated. Thus, a significant reduction in the overall flyover noise level can only be achieved by reducing the primary jet velocity and its accompanying jet noise. A cycle selection study was undertaken to evaluate the feasibility of reducing jet noise by varying the basic engine cycle to avoid producing the acoustic energy in the exhaust jet.

Several paths are theoretically available to reduce the jet velocity of a less-than-perfectly mixed common-flow-exhaust turbofan engine. These may be illustrated by considering the total thrust as the sum of theoretical bypass stream thrust and core stream thrust. (This simplification ignores the partial mixing which produces a gradient layer of air between the higher velocity core stream and the lower velocity bypass stream, for which the total thrust equation is modified when performing actual mixed stream thrust calculations.) At constant thrust, the three general paths that result in decreased primary stream jet velocities, indicated by this simplified illustration, are: increasing core stream airflow, increasing bypass stream jet velocity, or increasing bypass stream airflow.

The retrofit concept involved selecting a path which would require the least total number of parts to be changed. Due to the complexity of the core engine, it was apparent that the configuration changes required to reduce core jet velocity should be restricted to the fan section and bypass ducts. Thus, increasing core stream airflow was ruled out because core compressor modifications would be required. It would also have required reduced turbine temperature to achieve the core jet velocity reduction, which would have been inconsistent with the fact that the maximum capability of the core engine with respect to pressure, flow, and temperature levels must be used to maintain an efficient, competitive engine.

The selection of increased bypass stream airflow over increased bypass stream jet velocity involved evaluating the characteristics of the various types of noise produced by the engine components and the available means of reducing these noise levels. Increasing bypass stream jet velocity can only be accomplished by increasing the fan pressure ratio which would then increase fan generated turbomachinery noise. While fan noise could be minimized by the proper blade and vane spacing and by the proper choice of the number of blades and vanes in each row, increasing bypass stream jet velocity was not feasible because the single stage fan would not have the necessary pressure rise capability. The addition of a two-stage fan for the modified engine would result in an unacceptable increase in engine length due to the large axial spacing required.

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A single-stage fan with a larger diameter to increase bypass stream air flow was selected. To minimize the diameter increase and tip speed, the fan was designed for the highest levels of flow per unit area consistent with maintaining high efficiency levels in the range of cruise operation. The design pressure ratio was selected to maintain current stability levels. Bypass airflow was limited by several factors:

1) Engine low-pressure rotor shaft torque-carrying capabilities

2) Work extraction capabilities of the current three-stage, low-pressure turbine

The fan rotor diameter consistent with the airflow limits would have produced unacceptable stress levels in the rotor if operated at the current JT8D low rotor speed levels. Thus, it was necessary to slow the low rotor down to a speed consistent with acceptable fan stress levels. Although the lower rotor speeds could be accommodated within the new fan rotor design, compensation for the reduced core engine airflow pumping capability was required. Two new core low pressure compressor stages were required to maintain the current JT8D core airflow levels.

An extensive evaluation was undertaken to determine the feasibility of eliminating the inlet guide vanes, since this concept could be advantageous in reducing fan generated noise and the overall weight of the modified engine. It was concluded that, even though the inlet guide vanes may generate additional aft radiated fan noise, the full length fan duct of the JT8D engine provides sufficient area for peripheral acoustic treatment to attenuate the noise generated in the fan. The subsequent weight advantage of a non-inlet guide vane configuration had an insignificant effect on overall aircraft performance. Because of these conclusions, the inlet guide vane was retained, reducing the fan rotor tip relative Mach number, and providing increased core engine airflow pumping capability by adding preswirl at the root of the fan rotor.

The selected cycle, obtained by a combination of an increased diameter single-stage fan with inlet guide vanes, a full-length bypass duct, a single common flow exhaust nozzle, and two new core low compressor stages, doubled the amount of bypass air while maintaining current JT8D levels of core engine airflow, pressure rise, and turbine inlet temperatures. This cycle provided increased takeoffthrust and reduced cruise fuel consumption when cruise power requirements are high. The effectiveness of the higher bypass ratio in reducing cruise fuel consumption was partially counteracted by a reduction in low-turbine efficiency caused by increased work extraction at lower rotor speed, an increased level of turbine exit strut loss caused by incidence angles and increased local Mach number, and an increased fan exit guide vane pressure loss caused by the lower cruise fan operating line that results from a high bypass ratio, low exhaust pressure ratio cycle.

With both lower bypass and core stream jet velocities, the relative velocity between the two streams is similar to the current JT8D cycle. The predicted jet noise reductions assume that the amount of bypass/primary stream mixing is also similar to the current JT8D. Should an effective exhaust stream mixer be included in the design, further exhaust noise reductions would be possible.

B. ENGINE DESIGN

The JT8D-100 engine is a two-spool turbofan engine with a mechanically coupled fan and low-pressure compressor. It has a single-stage fan, six low-compressor stages and seven high-compressor stages. The compressor system generates a takeoff compressor pressure ratio of approximately 15.5 and a 2.1 bypass ratio. The burner section consists of nine separate combustion chambers in an annular array. The JT8D-100 derivative of a particular engine model uses the air-cooled or uncooled single-stage high-pressure turbine applicable for the rating of the particular conventional engine model, and a three-stage low-pressure turbine. Figure 1 is a cross section view of the JT8D-109 turbofan engine. Also shown in the figure are the instrumentation stations.

The JT8D-100 series engines were designed as low-noise retrofit configurations, obtainable from any of the current JT8D engine models. The fundamental design concept was to provide a higher bypass ratio engine which would lead to a lower jet exhaust velocity, and, therefore, lower jet noise. Fan and compressor noise levels were reduced through the elimination of a fan stage, increased fan rotor/exit guide vane spacing and the proper selection of blade and vane numbers. The fan noise was further reduced through the use of acoustical treatment forward of the fan rotor and downstream in the fan ducts.

1. Fan/Low Pressure Compressor

The JT8D-100 series fan is a single-stage unit with increased diameter, compared to current JT8D parts, to increase the fan bypass ratio. The blade design configuration is based upon current production engine design technology to minimize development risk. A wide-chord fan blade with a single part-span shroud was selected to reduce cost and achieve the aerodynamic requirements. This single-stage unit produces increased fan duct airflow at lower pressure and velocity than the two-stage JT8D fan configuration.

The new low-pressure compressor has six stages compared to four stages for the current JT8D engine. The compressor operates at a lower speed than the current engine to reduce noise and decrease the blade tip speed of the larger diameter fan. Two new stages were required to maintain the core engine pressure ratio and airflow rate at this lower speed with the single-stage fan assembly. These core engine characteristics are required to achieve the thrust level requirements at the reduced low-rotor operating speed.

Noise reduction was a major requirement governing various aspects of the fan/low compressor design. The numbers of blades and vanes in the fan and new low-compressor stages were selected to minimize noise generation. The axial spacing of these new stages was also selected to reduce noise generation. Acoustic treatment was incorporated into the fan duct walls fore and aft of the fan blade to reduce radiated noise.

2. High Pressure Compressor, Burner and Turbine

The seven-stage, high-pressure compressor, the can-annular burner, and the air-cooled or uncooled single-stage high turbine of the various current JT8D models were retained. The three-stage low-pressure turbine was retained, but the fourth-stage blade of the D-9, -11, -15 models was replaced to reduce the turbine rotor exit Mach number. The fourth-stage vane area has been increased to reduce the fourth-rotor airflow incidence angle. The present four exhaust case struts were recambered, and four additional exhaust struts have been added to further reduce exit swirl to the level being experienced on the current JT8D engine models. A revised low-turbine shaft material was required to maintain adequate strength at the increased torque. The maximum turbine temperature levels of the JT8D-100 derivative of a particular JT8D engine model are comparable to the levels for that particular current JT8D engine model.

3. Bearings and Support Structure

The No. 1 bearing and support structure have been redesigned for compatibility with the increased rotor length and larger diameter fan. All other bearings and their support structure remain unchanged.

4. Fan and Primary Engine Cases

Increased diameter fan cases were required for the increased diameter fan rotor. The current JT8D engine core engine cases were retained except in those instances where the core and fan cases are an integral assembly or the fan flow path requirement necessitated the redesign of the core engine case.

Acoustic treatment has been provided on the inner walls of the fan cases and the outer walls of certain engine core cases to reduce fan radiated noise.

5. Accessories

The high-rotor accessory gearbox, oil tank, oil pumps and oil system filters are the same as current JT8D engine models. The JT8D fuel control, fuel pump, fuel-oil cooler, fuel filters, bleed control and pressurizing valve were retained. The ignition system and the anti-icing and fuel de-icing valves from the current JT8D engine have also been retained. In conjunction with the increased diameter fan, the engine airbleed service pads located on the fan ducts were spaced radially outward at the same axial locations relative to the forward and rear mounts. Two additional fan bleed ports were required to satisfy airframe requirements.

6. Engine Instrumentation

Engine gas path instrumentation utilized during the JT8D-109 development program consisted of the following (Ref. Figure 1):

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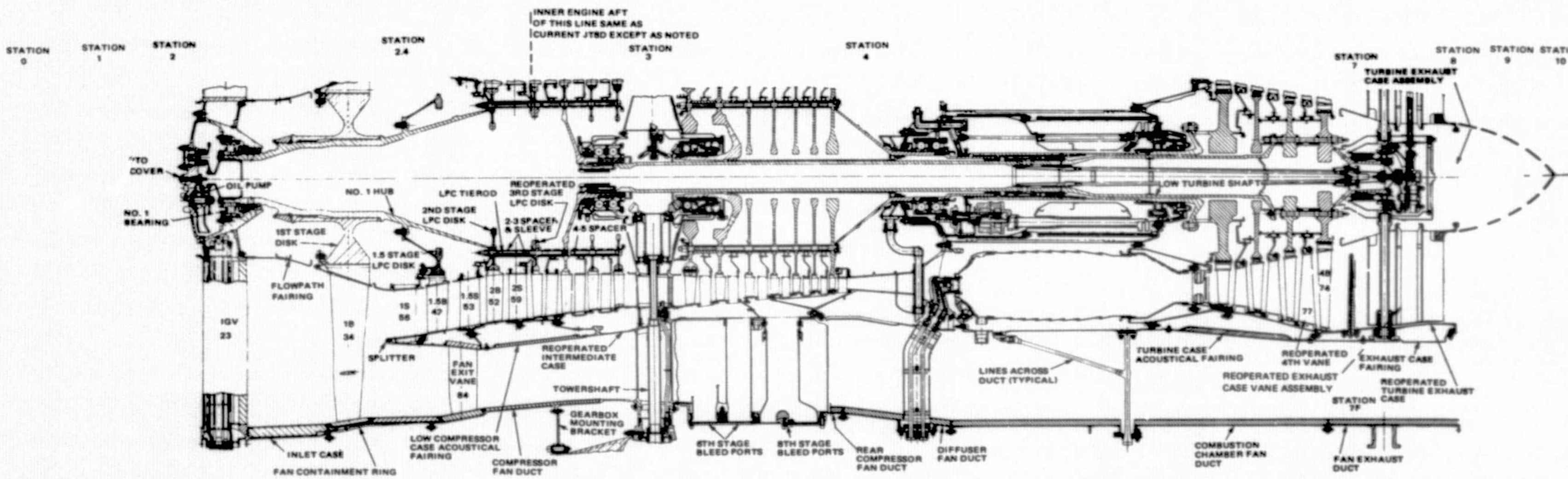

Figure 1 JT8D-109 Engine Cross Section

1) Station 1 – Engine Inlet Screen

- Twelve temperature probes

2) Station 2 – Engine Instrumentation Ring (secured to engine inlet case)

- Eight pitot - static probes

- Eight full-span PT2 rakes with 10 probes on each rake (for distortion testing as required).

3) Station 2.4 – Fan Discharge

- Four combination rakes with 10 total-pressure probes and 10 total-temperature probes on each rake

- Three static-pressure taps

4) Station 3 – Low-Pressure Compressor Discharge

- Four total-pressure rakes with 5 probes on each rake

- Four total-temperature rakes with 5 probes on each rake

5) Station 4 – High-Pressure Compressor Discharge

- Three total-pressure rakes with 4 probes on each rake

- Two total-temperature rakes with 4 probes on each rake

6) Station 7 – Turbine Discharge

- Six total-pressure probes manifolded together to provide an average primary exhaust total pressure

- Eight high-response, total-temperature probes measuring primary exhaust gas temperature, which can be read individually or as an average of all eight.

7) Station 7F – Fan Discharge

- Six total-pressure probes manifolded together to provide an average fan total exhaust pressure.

8) Bleed Ports

- Static pressure taps on the 6th, 8th and 13th-stage bleed port covers.

9) Burner

- One static pressure tap in the burner pressure sense line

10) Low- and High-Pressure Compressors

- Static pressure taps for measuring compressor discharge static pressure PS3 and PS4.

IV. ENGINE PERFORMANCE TESTING

As part of the system development program, JT8D-100 engine testing was conducted to determine the performance characteristics of the refan engine. Testing was conducted at Pratt & Whitney Aircraft sea level test facilities, at the NASA LeRC altitude test facility, and at McDonnell-Douglas in a DC-9 aircraft.

The performance criteria for the JT8D-100 refan program included goals of increasing sea level static standard day takeoff thrust from 14500 lbs for a standard JT8D-9 engine to 16,600 lbs for the refanned D-109 engine and from 15,500 lbs for a standard JT8D-15 to 17,500 lbs for the refanned D-115 engine. This increase in takeoff thrust was to be accompanied by a reduction in TSFC of 12.66% for the JT8D-109 and 13.8% for the JT8D-115. At altitude (30000 ft, 0.8 Mn) the JT8D-100 cycle was to increase cruise thrust by 5% and reduce TSFC by 1.25%. Similar thrust increases and TSFC reductions were to be obtainable by retrofitting any current JT8D engine model to a refan configuration. The JT8D-109/115 goals are stated here since these were the engines tested in the program.

Because the refan program was structured around a retrofit concept, the most meaningful evaluation of refan performance was on a percent improvement basis. The high compressor, high turbine, combustor, and parts of the low compressor and low turbine were essentially unchanged in the conversion from base engine to the refan configuration. Therefore, the performance of the refan engine was dependent to a large extent on the performance of the unchanged parts which could vary significantly according to their state of deterioration.

The JT8D-109 design goal performance predictions were based on JT8D-9 performance demonstrated by the average 1971 production engine. Based upon this criterion, takeoff TSFC would decrease from 0.5694 for a JT8D-9 to 0.4973 (-12.66%) for a JT8D-109.

A. SEA LEVEL STATIC TESTING

Sea level static performance testing was conducted at P&WA on refan engines EE-1, EE-2 and EE-3 as both JT8D-9 and JT8D-109 models to establish the performance characteristics of the JT8D-109 engine in comparison to the JT8D-9 engine. After conversion, testing was also conducted on the two JT8D-109 engines used for DC-9 flight testing and the one JT8D-115 engine used for Boeing ground testing. These engines were not calibrated as base models immediately prior to conversion to the JT8D-100 configuration.

1. Test Procedure

Steady state performance data were recorded in 1000 lb. thrust increments from 4000 lbs of observed thrust to maximum power. A seven-minute stabilization time was observed at each power condition prior to data acquisition. Performance data were acquired through the use of the Steady State Data Aquisition System (SSDAS). Engine instrumentation was connected to a pressure measuring subsystem and an electrical subsystem. These systems were in turn connected to a central computer. Raw data plus selected computed results were sent back to the stand high speed printer for on-stand data validity checks and analysis during the test.

2. Test Results and Discussion of Results

Initial performance calibrations on engines EE-1 and EE-2 indicated that the fan operating line was approximately 3% higher than predicted. This resulted in loss of fan surge margin and lower than anticipated fan efficiency. To alleviate this condition, the engine area ratio was increased 26% and the jet nozzle area increased from 8.08 sq. ft. to 8.33 sq. ft. (The engine area ratio is defined as the ratio of fan flow area to engine flow area, measured at the tailpipe mixing plane.) In addition to these modifications, the tip clearances on rotors 1.5 and 2.0 were increased due to blade tip rubs encountered in the initial testing. To reduce the impact of increased clearances on engine performance, "squealer cuts" were incorporated on the cut-back blade tips. The squealer cut was made by removing approximately 0.050 in. of material on the blade tip concave surface. This cut reduced the blade-to-shroud annular ring effective area, thereby reducing tip leakage.

A final modification was made after analysis of fan/LPC rig data indicated the low compressor flow capacity to be approximately 3% below design goals. It was determined that stator 1 and, to a lesser extent, rotor 1.5 and stator 1.5 were operating closer to a choke condition than anticipated. To help alleviate this problem, the 1st stator vanes were restaggered open three degrees relative to initial design specifications.

Test results subsequent to these reoperations indicated that the low compressor flow capacity increased by 1.5 to 2.0%. Table I shows the percent TSFC improvement demonstrated by all refan engines with the modifications mentioned above, compared to the base engine model (JT8D-9 or JT8D-15). Figures 2 through 4 present the SLS TSFC curves for EE-1, EE-2 and EE-3 tested at P&WA in both the JT8D-9 and JT8D-109 configurations with the modifications mentioned above.

TABLE I

JT8D-109/D-9 THRUST SPECIFIC FUEL CONSUMPTION COMPARISON

Model	Engine	Base Model Configuration Takeoff TSFC (lb/hr/lb)	Refan Configuration Takeoff TSFC (lb/hr/lb)	Δ	Δ%
JT8D-9/109	Design Goal	0.5694	0.4973	−0.0721	−12.66
JT8D-15/115	Design Goal	0.601	0.518	−0.083	−13.5
JT8D-9/109	EE-1	0.596	0.524	−0.072	−12.1
JT8D-9/109	EE-2	0.593	0.522	−0.071	−12.0
JT8D-9/109	EE-3*	0.578	0.509	−0.069	−12.0
JT8D-9/109	P-666995**	0.572	0.526	−0.046	− 8.1
JT8D-9/109	P-666996**	0.566	0.513	−0.053	− 9.4
JT8D-15/115	P-687547***	0.602	0.528	−0.074	−12.3

NOTES:

* The above data reflect EE-3 performance as a JT8D-9 with production instrumentation plus experimental instrumentation at stations 4 and 7F. As a JT8D-109 engine it was tested with full experimental instrumentation. The effects of this additional instrumentation will be addressed later in this section.

** These engines were tested in the JT8D-9 configuration in 1971. They were delivered to McDonnell-Douglas Corporation and accumulated approximately 115 hours of running time. The table shows Δ performance based on the 1971 engine calibration. The performance of these engines as JT8D-9 engines immediately prior to conversion is unknown.

*** This engine was tested in the JT8D-15 configuration in June 1974. It was delivered to The Boeing Company and accumulated approximately 30 hours of ground test running time. The table shows Δ performance based on the June 1974 engine calibration. The performance of this engine as a JT8D-15 engine immediately prior to conversion is unknown.

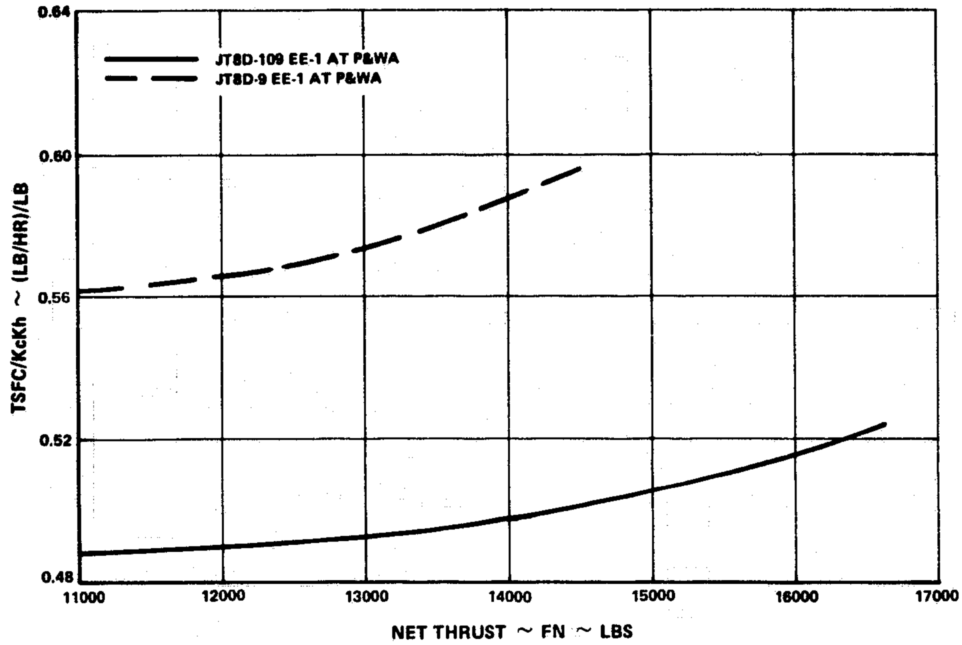

Figure 2 JT8D-109/D-9 Engine EE-1 Steady State Static Sea Level Performance

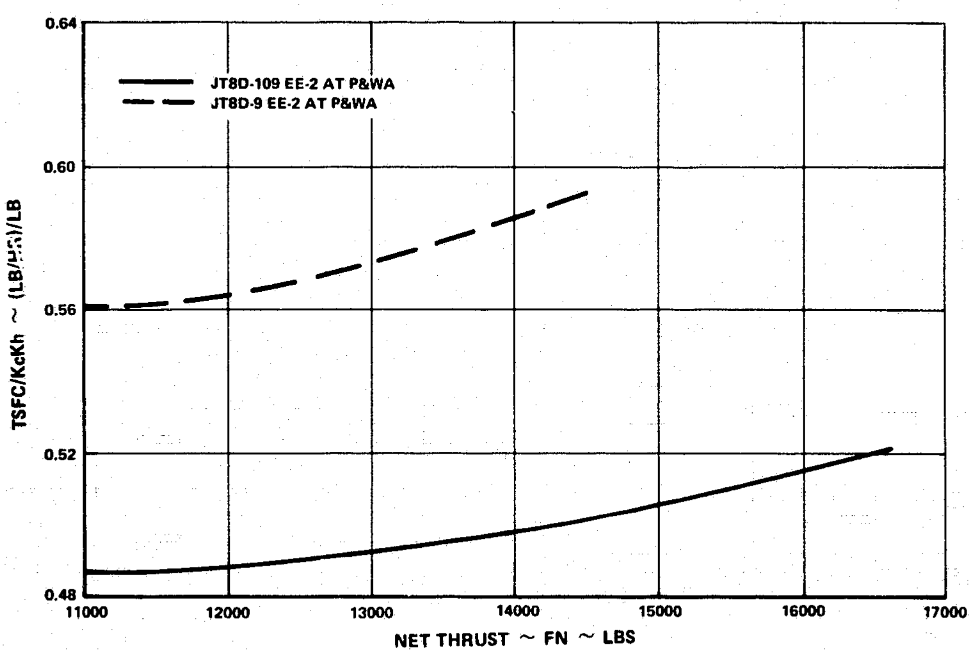

Figure 3 JT8D-109/D-9 Engine EE-2 Steady State Static Sea Level Performance

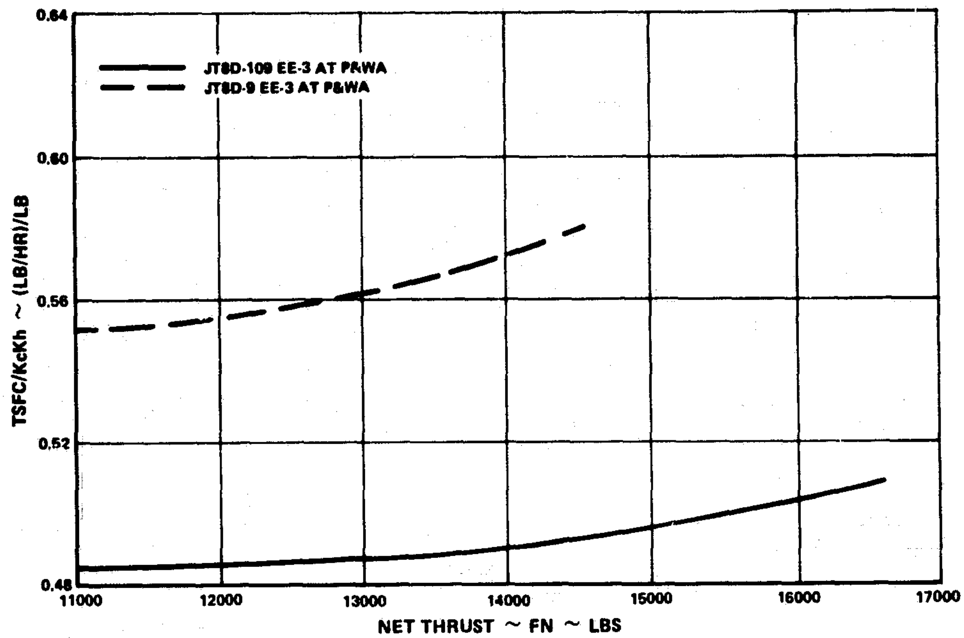

Figure 4 JT8D-109/D-9 Engine EE-3 Steady State Static Sea Level Performance

Engine EE-3 was the only engine tested at both sea level and simulated altitude conditions with sufficient experimental instrumentation to perform component performance analysis. Test results from this engine test program, therefore, permit the most comprehensive evaluation of refan engine performance and will represent the bulk of the discussion presented in this section. Additional sea level static test results from engines EE-1 and EE-2 and the flight test engines will be presented as required to complete the performance analysis of the JT8D-109 engine.

Engine EE-3 was a new JT8D-9 engine, produced in 1974. When calibrated as a D-9 engine it demonstrated a TSFC at 14,500 lb. FN (D-9 takeoff rating) of 0.5784. This value was 1.6% higher than the 1971 JT8D-9 production average TSFC level of 0.5694 which was used in the refan design studies as typical, or baseline, JT8D-9 performance. There were two minor differences between engine EE-3 and the standard production engine configuration. Engine EE-3 had two experimental instrumentation probes inserted through the fan ducts and into the primary gas stream at station four to record total pressure and temperature at the exit of the high compressor. Engine EE-3 was also equipped with total pressure probes at station 7F to record fan duct exit total pressure. The performance penalty due to the pressure loss generated by this experimental instrumentation was not measured but is considered small. Table II summarizes engine EE-3 performance as a JT8D-9 relative to the average 1971 production engine.

TABLE II

JT8D-9 PERFORMANCE COMPARISON
ENGINE EE-3 VERSUS 1971 AVERAGE PRODUCTION ENGINE

Parameter	EE-3 as a D-9	1971 Prod. Avg.	% Diff.
$FN/\delta T2$ (lbs)	14500	14500	0
TSFC/Kc Kh @18400 LHV (lb/hr/lb)	0.5784	0.5694	+1.6
TT5 (°R)	2257	2227	+1.4
$N1/\sqrt{\theta T2}$ (rpm)	8010	8028	−0.2
$N2/\sqrt{\theta T2}$ (rpm)	11402	11400	0
PT7/PT2	2.015	2.025	−0.5
PS3/PT2	3.43	3.469	−1.1
PS4/PT2	15.2	15.28	−0.5
$TT7/\theta T2$(°R)	1413	1407	+0.4

After conversion to a JT8D-109 configuration, EE-3 demonstrated the following at the JT8D-109 sea level static takeoff thrust rating of 16,600 lb:

- TSFC/KcKh =0.5053
- Corrected to 18400 BTU/lb LHV = 0.5089
- Corrected for the presence of experimental instrumentation = 0.5046

Therefore if the takeoff TSFC of EE-3 is adjusted for the pressure loss penalty induced by the presence of experimental instrumentation the TSFC improvement shown due to the refan conversion is:

$$\text{TSFC improvements} = [(0.5784 - 0.5046)/0.5784] \times 100 = 12.76\%$$

Comparing this with the previously stated design goal of 12.66% improvement indicates that EE-3 did achieve this design goal.

Table III presents the more significant performance parameters demonstrated on EE-3 compared to the original performance goals.

TABLE III

JT8D-109 ENGINE EE-3
MEASURED PERFORMANCE COMPARISON WITH DESIGN GOALS
(SLS TAKEOFF)

Parameter	JT8D-109 Design Goal	JT8D-109 EE-3 Measured	Δ Parameter	Δ TSFC Impact
TSFC/Kc Kh	0.4973	0.5089	+2.3%	
$TT5/\theta T2$ (°R)	2226	2285	+59°	
$N1/\sqrt{\theta T2}$, (rpm)	7450	7340	−110	
$N2/\sqrt{\theta T2}$, (rpm)	11240	11400	+160	
$WAT\sqrt{\theta T2}/\delta T2$, (lbs/sec)	467	468	+1	
$WAE\sqrt{\theta T2}/\delta T2$ (lbs/sec)	156	150	−6	
ηFan(%)	82.45	84.95	+2.5	−1.2%
ηLPC(%)	86.61	86.28	−0.33	+0.2%
ηSTO(%)	89.36	88.61	−0.75	+1.4%
ΔP/P(PT2.4 - PT7F)/PT2.4	0.042	0.064	+0.022	+2.2%
Gross Thrust Coefficient (CV)	0.980	0.984	+0.004	−0.4%

As can be seen from Table III, the TSFC differences from the design goals primarily resulted from turbine efficiency and fan duct (including fan exit guide vanes) pressure loss penalties. These losses were partially offset by an improved fan efficiency. When tested as a JT8D-9, engine EE-3 was not sufficiently instrumented to define the component performance in detail; however, computer simulations indicated JT8D-9 base line performance was deficient in terms of LPC and turbine efficiencies which would impact refan performance in a similar manner. In addition, the 2.2% duct loss increase can be reduced to 1.5% after an adjustment is made for instrumentation losses. Therefore, it is concluded from EE-3 testing that the -1.2% ΔTSFC impact due to the fan efficiency improvement of 2.5% over design goals was offset by a ΔTSFC of +1.5% due to a fan stream pressure loss increase of 1.5%. Analysis of full scale JT8D-100 fan/LPC rig wake rake survey data behind the fan exit guide vanes indicated that the exit guide vane loss was approximately 0.5% higher than predicted, leaving the fan duct loss about 1% higher than predicted.

Unlike TSFC, the turbine inlet temperature (TT5) difference noted in TABLE III would not be eliminated entirely by baseline performance differences and offsetting component performance shifts. The TT5 difference between EE-3 in the baseline and refan configurations at the takeoff rating was +30°F after these adjustments. This remaining 30° can be attributed to fan core region deficiencies noted during fan/LPC rig testing (only partially offset by the first stator vane restagger) and the reduction in takeoff rotor speed from 7450 rpm to 7340 rpm for the exhaust system match which together reduced primary flow 6 lb/sec (4%).

Table IV presents the more significant component performance parameters demonstrated on JT8D-109 engines EE-1 and EE-2 compared to EE-3.

TABLE IV

JT8D-109 MEASURED PERFORMANCE COMPARISON (SLS TAKEOFF)

Parameter	EE-1	EE-2	EE-3
$N1/\sqrt{\theta T2}$ (rpm)	7350	7400	7340
$N2/\sqrt{\theta T2}$ (rpm)	11430	11470	11400
$WAT\sqrt{\theta T2}/\delta T2$ (lbs/sec)	468	468	468
$WAE\sqrt{\theta T2}/\delta T2$ (lbs/sec)	147	147	150
ηFan%	83.80	84.45	84.95
ηLPC%	86.90	85.80	86.28
ηSTO%	88.60	88.30	88.61
$\Delta P/P$(PT2.4 - PT7F)/PT2.4	0.057	0.058	0.064

Engines EE-1 and EE-2 indicated similar component performance trends to EE-3 with somewhat less improvement in fan efficiency but improved fan stream pressure loss levels.

During SLS engine development testing abnormal fan performance modes characterized by a loss in flow capacity up to 5% and a loss in fan O.D. efficiency of up to 8% were observed on EE-1 and EE-2. These modes occurred only at low rotor speeds above 7000 rpm. There was no measurable loss in stability. The abnormal performance was not observed during the fan/LPC rig program, nor in the testing of the other four engines in the program.

The abnormal fan mode was observed to develop either gradually or as a discontinuous loss in fan performance. Accompanying changes in gas generator characteristics were evident and consistent with the loss in fan flow capacity and fan efficiency. The change back to normal performance was usually noted upon power reduction, however a trend toward a gradual change back was observed on some occasions.

Spanwise performance data taken during abnormal performance conditions indicated that, while the entire fan duct portion of the fan blade was affected. the greatest loss in efficiency occurred just under the part-span shroud. While no conclusive evidence exists, it appears that some complex mechanism produces shock wave spillage or partial span rotating stall when the fan operates in this mode. Possible causes for the spillage are condensation shocks in the presence of humidity, inlet vortices, and/or complex system unsteadiness. Rotating stall could be caused by FEGV and duct system instabilities, air leakage around the FEGV root, or discontinuities in the duct I.D. wall aggravated by thermals or ovalization of cases. These hypotheses have not been investigated under controlled conditions with adequate instrumentation; consequently, configuration changes to eliminate the characteristic have not been established. These configuration changes would have to be established as part of any future program to certify the JT8D-109 engine model.

B. ALTITUDE TESTING

1. Test Procedure

Engine EE-3, after being baseline tested at the P&WA facility, was moved to the NASA LeRC for testing at altitude conditions. Steady state performance testing of EE-3 was conducted at the flight conditions shown in Table V. Steady state data were acquired at the specified altitude and Mach No. conditions over a range of approximately 8 throttle settings from idle to take-off power.

TABLE V

JT8D-109 ENGINE EE-3
TEST CONDITIONS

Altitude (ft.)	Mach No.
10,000	0.1
10,000	0.4
15,000	0.5
19,000	0.2
25,000	0.6
25,000	0.8
30,000	0.4
30,000	0.7
30,000	0.8
30,000	0.85
35,000	0.7
35,000	0.85
35,000	1.05
40,000	0.85

2. Test Results and Discussion of Results

Analysis of results was complicated by two basic uncertainties in the data. First, there was a 3-3.5% variation (scatter) in TSFC values at constant thrust. "Average" lines were constructed through these data sets, but an undetermined level of uncertainty is contained in each "average" value. Secondly, the facility airflow measuring system required adjustments for the presence of static and total pressure gradients in the facility inlet duct to the engine. These gradients were not measured by the boundary layer instrumentation used in determination of airflow. The data presented have been adjusted by decreasing the measured total airflow by approximately 1.25%.

Figures 5 through 9 present thrust vs. fuel consumption test results at flight conditions in and around the airplane cruise environment. The results can be summarized by noting that the as-measured results show a deficiency of 2-3% in TSFC at the average cruise thrust setting of all the cruise conditions tested, except the 25,000 ft 0.8 Mn condition. A 4.7% deficiency at the 25,000 ft 0.8 Mn condition is not consistent with other average cruise conditions. Data analysis indicated this was due to a lower thrust indication at this condition. These data are considered questionable.

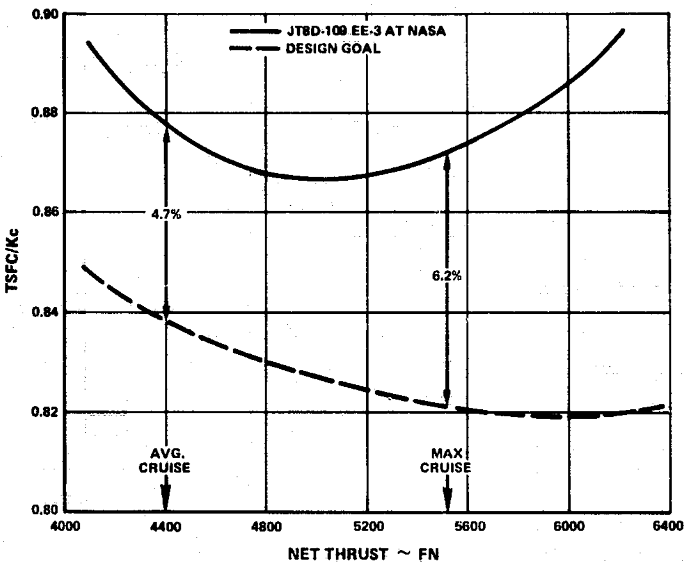

Figure 5 JT8D-109 Engine EE-3 Steady State Performance Evaluation at 25000 Ft. Mn 0.80

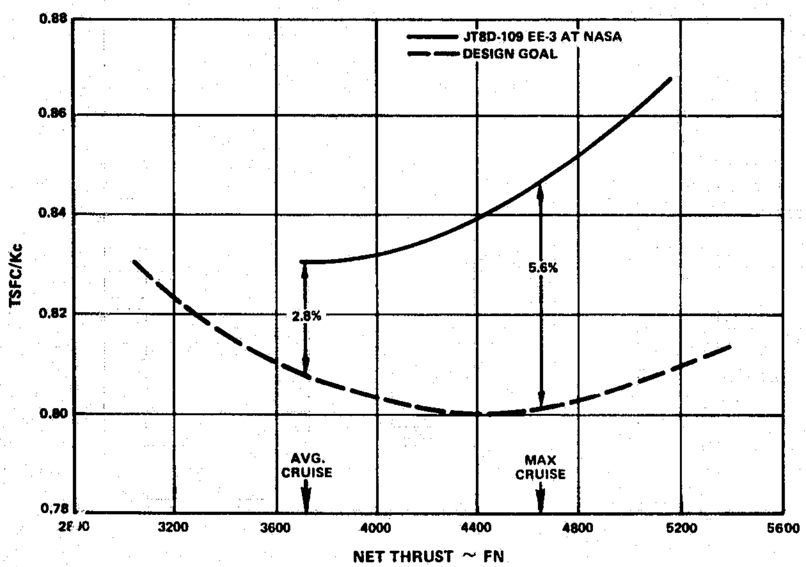

Figure 6 JT8D-109 Engine EE-3 Steady State Performance Evaluation at 30000 Ft. Mn 0.70

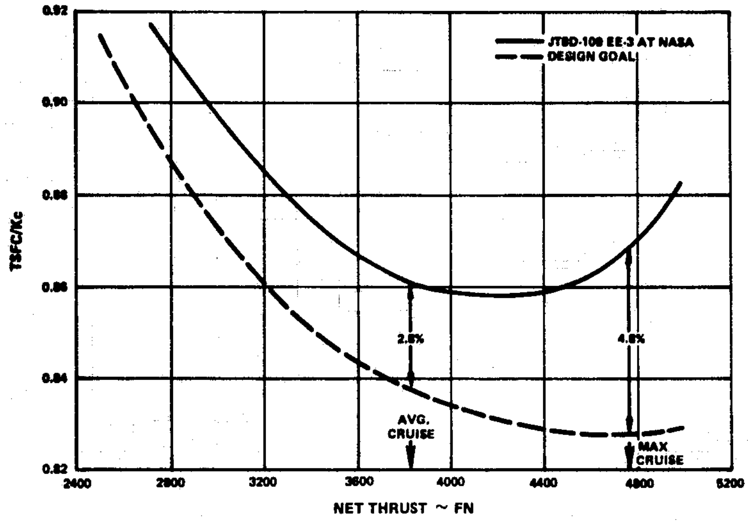

Figure 7 JT8D-109 Engine EE-3 Steady State Performance Evaluation at 30000 Ft. Mn 0.80

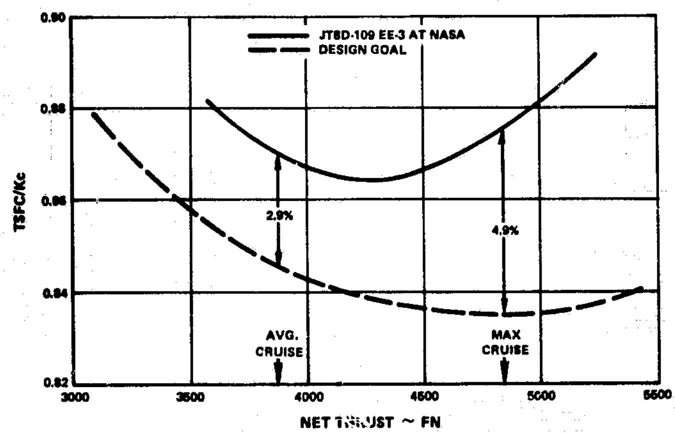

Figure 8 JT8D-109 Engine EE-3 Steady State Performance Evaluation at 30000 Ft. Mn 0.85

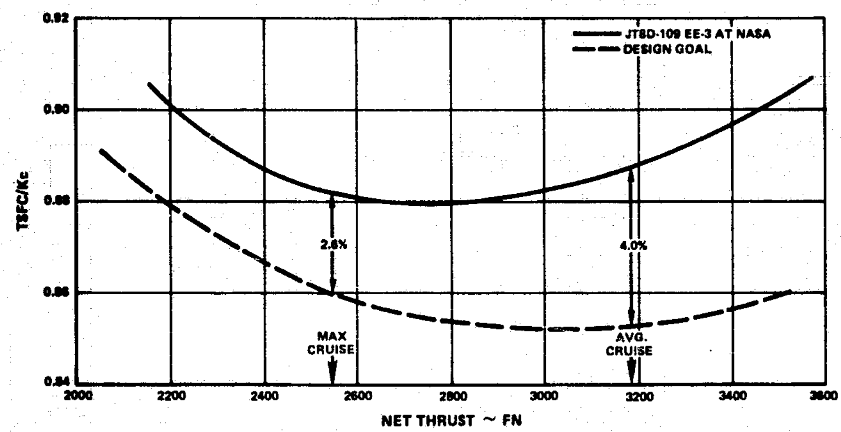

Figure 9 JT8D-109 Engine EE-3 Steady State Performance Evaluation at 40000 Ft. Mn 0.85

Engine EE-3 at sea level static showed an as-run deficiency of approximately 2.3% in TSFC relative to the design goal. Based on this, it can be concluded that EE-3 was approximately 0.5% higher than the design sea-level-to-altitude TSFC increment at average cruise power. A 4-6% deficiency exists at the maximum cruise thrust setting. Thus, at maximum cruise power, the TSFC was 1.7% to 3.7% higher than the design sea level-to-altitude TSFC increment at maximum cruise power. Tables VI and VII show the measured vs. design goal values of important parameters for average cruise and maximum cruise power at 30,000 ft 0.8 Mn.

TABLE VI

JT8D-109 ENGINE EE-3
MEASURED TEST RESULTS VERSUS DESIGN GOAL
COMPARISON AT AVERAGE CRUISE
(30,000 ft., 0.8 Mn)

Parameter	Measured Data	Design Goal	Δ Parameter	Δ TSFC Impact
TSFC/Kc	0.861	0.838	+2.8%	
$TT5/\theta T2$ (°R)	2150	2134	+16	
$N1/\sqrt{\theta T2}$ (rpm)	7140	7230	−90	
$N2/\sqrt{\theta T2}$ (rpm)	11030	11050	−20	
$WAT\sqrt{\theta T2}/\delta T2$ (lbs/sec)	461	459	+2	
$WAE\sqrt{\theta T2}/\delta T2$ (lbs/sec)	142	147	−5	
η Fan (%)	82.15	81.82	+0.33	−0.1
η LPC (%)	86.40	86.24	+0.16	−0.1
η STO (%)	88.88	89.34	−0.46	+0.8
ΔP/P(PT2.4–PT7F)/PT2.4	0.075	0.055	+0.02	+1.6
Gross Thrust Coefficient (CV)	0.988	0.988	0	0

TABLE VII

JT8D-109 ENGINE EE-3
MEASURED TEST RESULTS VERSUS DESIGN GOAL
COMPARISON AT MAXIMUM CRUISE
(30,000 ft., 0.8 Mn)

Parameter	Measured Data	Design Goal	Δ Parameter	Δ TSFC Impact
TSFC/Kc	0.868	0.828	+4.8%	
$TT5/\theta T2$ (°R)	2335	2295	+40	
$N1/\sqrt{\theta T2}$ (rpm)	7670	7735	−65	
$N2/\sqrt{\theta T2}$ (rpm)	11430	11400	+30	
$WAT\sqrt{\theta T2}/\delta T2$ (lbs/sec)	485	479	+6	
$WAE\sqrt{\theta T2}/\delta T2$ (lbs/sec)	154	158	−4	
η Fan (%)	81.04	80.72	+0.32	−0.1
η LPC (%)	83.00	82.82	+0.18	−0.1
η STO (%)	89.40	89.25	+0.15	−0.2
ΔP/P(PT2.4–PT7F)/PT2.4	0.0985	0.0574	+0.0411	+2.9
Gross Thrust Coefficient (CV)	0.9871	0.9903	−0.032	+0.6

As previously noted at SLS, the combination of other refan component changes, instrumentation adjustment and base JT8D-9 performance differences offset a fan stream pressure loss increase above design goals of about 2%. However, at max cruise the additional 2% increase in fan stream pressure loss above the SLS and average cruise tested levels would account for an additional 1.3% TSFC discrepancy. As noted in Table VII, the gross thrust coefficient, which characterizes in an overall fashion the partially mixed flow exhaust system performance, contributed an additional 0.6% to the TSFC discrepancy.

When the altitude cruise data were originally taken in October of 1974, the cruise discrepancies were approximately 2% larger than indicated above. Since the JT8D had never been calibrated under simulated altitude conditions with direct force measurement to calculate thrust, and the contribution of fan stream discharge, turbine discharge, and exhaust stream discharge pressure losses, fan and turbine discharge stream mixing, and residual turbine swirl were not defined by the gas path instrumentation available, an exhaust system pressure and temperature traverse survey was conducted. Although subsequent correction of airflow and thrust for static and total pressure gradients in the NASA LeRC altitude facility inlet duct alleviated a major concern, traverse programs were conducted at NASA and P&WA in December 1974 and January 1975.

In December of 1974, a station seven pressure traverse was conducted on JT8D-109 EE-1 to determine fan and engine pressure levels at the turbine and fan discharge plane upstream of the nozzle exit. Traverses were conducted with a standard exhaust nozzle (8.33 sq. ft.) and with a 10% larger nozzle selected to provide corrected flow conditions at the traverse plane equivalent to those at cruise conditions.

Data were obtained at 15 radial locations for seven circumferential positions of the traversing probe. Total pressure was then averaged using a stream thrust integrating routine. The fan stream integration agreed quite well with the values used in the test data analyses, the traverse data giving slightly higher losses. The engine stream traverse, however, implied levels so low it would be impossible for the engine to achieve the measured levels of thrust.

The problem with the engine stream traverse appeared to be turbine exit guide vane (TEGV) tip vortices due to a gap between the vanes and the case. It is theorized that these holes in the total pressure map might be due to flow angularity relative to the pressure probe rather than a total pressure loss. Hence, including them into the integration produced an erroneous pressure level. Because of this, the decision was made to continue to use turbine discharge pressure levels taken earlier during a more detailed traverse on JT8D-109 EE-2. This turbine exit traverse indicated a 3.66% primary pressure loss. Measurements of strut fairing leading and trailing edge metal angles at this time indicated significant deviation from design values. This change in metal angle and the unsealed radial gaps at the thin vane tips account for the pressure loss level.

The 3.66% pressure loss was used on EE-3 when analyzing exhaust system performance. Because the fan duct did not have these complex flow patterns, fan duct discharge pressure loss levels from the traverse data from JT8D-109 EE-1 were used on EE-3 when analyzing exhaust system performance.

The fan stream traverse results confirmed the PT7F test data that fan duct pressure loss did not vary directly with the average duct $(Mn)^2$, as was assumed in making the original refan performance prediction. As noted above, the performance loss at altitude maximum cruise power relative to average cruise is primarily due to the increased duct pressure loss which was not anticipated based on the $(Mn)^2$ pressure loss relationship.

Exhaust nozzle discharge traverse results were obtained at simulated cruise conditions on EE-3 at NASA. Analysis of the data indicated that the measured facility thrust to airflow ratio was within 0.5% of the traverse calculated thrust to airflow ratio, thus matching the average exhaust velocity at the nozzle exit. The absolute integrated gross thrust and total airflow levels as obtained from the traverse data, however, were both 4% below measured facility values.

C. FLIGHT TESTING

Two JT8D-109 engines, P-666995 and P-666996, were delivered to McDonnell-Douglas for flight test in a modified DC-9 airplane. As can be seen from Table I, the TSFC at SLS take-off power was considerably higher than the design goal, 5.8% for engine P-666995 and 3.2% for engine P-666996. This is an average value of 4.5% higher than the design goal for the air-plane propulsion system. EE-3, which demonstrated a 2.3% TSFC deficiency (as-run) at SLS takeoff, had a 2.8% (as run) deficiency at 30,000 ft. average cruise rating. Based on a straight ratio of these values, the airplane TSFC deficiency would be expected to be 5.4% at 30,000 ft. average cruise power.

D. POTENTIAL JT8D-100 PERFORMANCE IMPROVEMENTS

If a decision were made to proceed towards certification of the JT8D-100 engine series, extensive development testing would be conducted to evaluate performance improvement configurations. Potential performance improvement items that have been identified as a possible means to improve the deficiencies noted in the NASA refan programs are shown in Table VIII.

TABLE VIII

POTENTIAL JT8D-100 PERFORMANCE IMPROVEMENTS

Item	Pressure Loss Reduction (%)	Efficiency Improvement (%)	Δ Weight Increase (lbs)	Δ TSFC* Improvement (%)	Δ TT5** (°F)
Fan Rotor			2.0	0.9	–16
(a) Recontour core flow region of airfoil		3.0 primary			
(b) Conical shroud Streamline shroud Recontour airfoil below shroud		1.6 duct			
FEGV	0.6		1.0	0.4	–4
(a) Recontour spanwise					
(b) Root sealing					
Fan Duct Flowpath	1.1		14.0	0.8	–8
(a) Inner – Constant diameter from intermediate case to burner case					
(b) Outer – Increased inner diameter, intermediate to split fan burner case					
Combined PT7/TT7 Probes fore or aft of exhaust strut	1.0		1.6	0.4	–4
Summation			18.6	2.5	–32

* 30,000 feet, 0.8 Mn

** Sea Level Static, Takeoff

V. ENGINE STARTING, TRANSIENT AND STABILITY TESTING

As part of the System Development Test Program, JT8D-109 engine starting, transient and stability testing was conducted by Pratt & Whitney Aircraft at sea-level static conditions, and by NASA LeRC at appropriate altitude test conditions. Selected data from the DC-9 flight testing are also included in this document.

A. GROUND STARTING TESTS

Sea level static tests were conducted at P&WA on engines EE-1, EE-2 and EE-3 as both JT8D-9 and JT8D-109 models to establish the ground starting characteristics of the JT8D-109 engine in comparison to the baseline JT8D-9 engine.

1. Test Procedure

Normal engine starts were accomplished to document starting time-to-idle. The following were recorded:

1) Starter drive pressure level
2) Time to pressurization
3) N1 speed at pressurization
4) N2 speed at pressurization
5) Time to engine light-off
6) Maximum fuel flow
7) Maximum exhaust gas temperature
8) Time to idle – to within 100 rpm of the N2 defined by the idle trim curve

2. Test Results and Discussion of Results

The results of the JT8D-9 and JT8D-109 engine ground starting tests are shown in Table IX. These results are consistent with typical JT8D-9 experience.

TABLE IX

JT8D-9/D-109 GROUND STARTING TIMES (SECONDS)*

	JT8D-9			JT8D-109		
Start No.	Typical D-9	EE-1	EE-2	EE-1	EE-2	EE-3
1	–	36	40.6	32.2	40.5	43.6
2	–	39.5	38.7	33.7	39.0	50.5
3	–	40.5	36.8	41.4	39.0	39.0
		38.7	38.7	35.8	39.5	44.3
Average	30-50	38.7			39.9	

*Timed from starter pressurization to idle N2 minus 100 rpm

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Table X shows a comparison of the baseline JT8D-9 and refan JT8D-109 maximum exhaust gas temperature levels during ground start. These results are consistent with typical JT8D-9 experience.

TABLE X

JT8D-9/D-109 MAXIMUM EXHAUST GAS TEMPERATURES (°F) DURING GROUND STARTING

JT8D-9		JT8D-109	
EE-1	EE-2	EE-1	EE-2
575	663	582	680

Additional representative JT8D-109 ground starting characteristics are compared to the JT8D-9 characteristics in Figures 10 and 11.

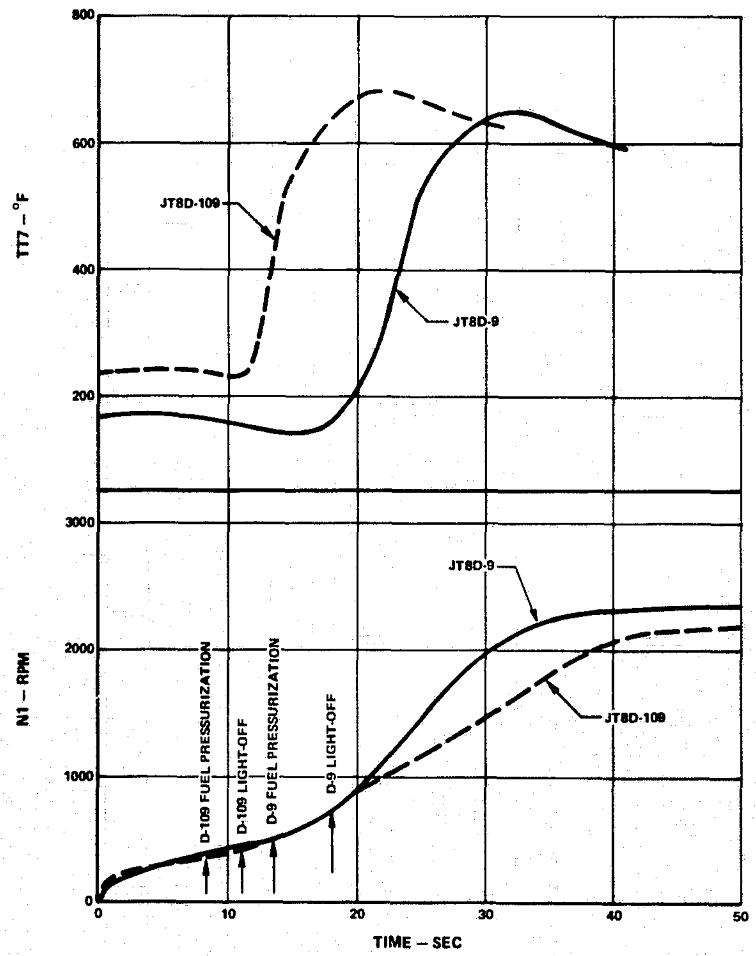


Figure 10 JT8D-109/D-9 Typical Ground Starting Characteristics

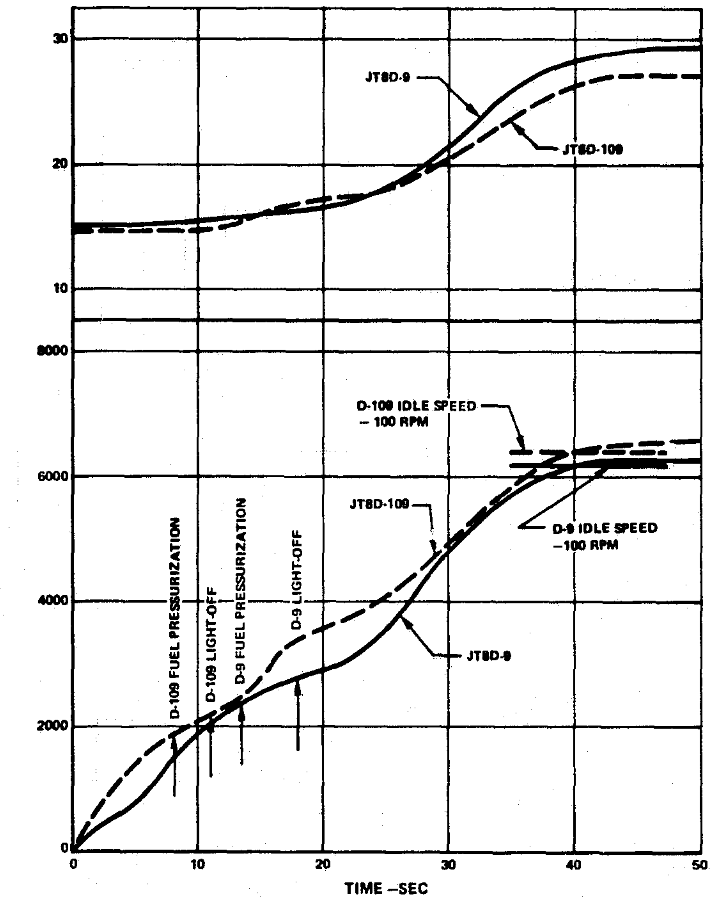


Figure 11 JT8D-109/D-9 Typical Ground Starting Characteristics

B. FLIGHT STARTING TESTS

Flight starting tests were conducted on JT8D-109 refanned engine EE-3 at the NASA Lewis Research Center (LeRC) altitude test facility. These tests were performed to demonstrate the capability of the JT8D-109 engine to start in flight without starter assist throughout the current JT8D-powered aircraft flight start envelope as shown in Figure 12.

Three categories of flight starting tests were conducted:

1) Engine windmilling with TT7 - TT2 ≈ 0°F (cold airstart)
2) Engine windmilling with TT7 - TT2 ≈ 100°F (airstart)
3) Engine windmilling, restart after 45 sec shutdown from cruise power (relight)

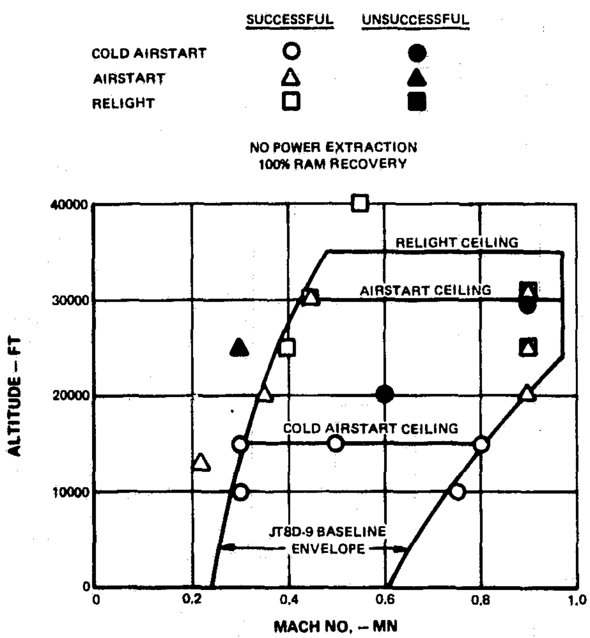


Figure 12 JT8D-Powered Aircraft Flight Start Envelope

1. Test Procedures

a. Cold Engine Airstart

Cold engine airstarts were accomplished from a free windmilling condition where TT7-TT2 across the engine was as close to zero as practical. An inlet distortion screen simulating the Boeing 727 center engine inlet distortion was utilized during the test. The test was conducted as follows:

1) Test cell conditions (PT2, PO and TT2) were set with the bulkhead valve opened sufficiently so that total flow was 10 to 20 percent above idle value.

2) Steady state data were recorded at the windmilling condition. While recording transient data, an engine start and acceleration to idle was accomplished.

3) The engine was shut down upon reaching idle so as to obtain minimum ΔT (TT7-TT2) as quickly as possible for the next start.

4) The above procedure was repeated with variations in Mn to establish the start-no start envelope, Ref. Table XI.

TABLE XI

JT8D-109 COLD AIRSTART TEST CONDITIONS

Altitude (ft)	Mn	TT2 (°F)
10,000	0.30	30
10,000	0.75	53
10,000	0.75	51
10,000	0.75	58
15,000	0.30	9
15,000	0.50	28
15,000	0.80	53
15,000	0.80	55
15,000	0.80	61
20,000	0.60	18
30,000	0.90	18

b. Engine Airstart

Engine airstart testing was conducted to simulate engine starts after engine shutdown from cruise power when the ΔT (TT7-TT2) across the engine was approximately 100°F. An inlet distortion screen simulating the Boeing 727 center engine inlet distortion was utilized during the test. The test was conducted as follows:

1) Test conditions were set with the bulkhead valve slightly open.

2) A steady state data point was recorded at cruise power.

3) While recording transient data, the engine was shut down. A relight was attempted when the engine ΔT was approximately 100°F. The engine was then accelerated slowly to cruise power.

4) The above procedure was repeated with variations in Mn to establish the airstart envelope. Ref. Table XII.

TABLE XII

JT8D-109 AIRSTART TEST CONDITIONS

Altitude (ft)	Mn	TT2 (°F)
14,000	0.22	42
20,000	0.35	45
20,000	0.35	42
20,000	0.90	52
25,000	0.30	41
25,000	0.90	45
25,000	0.90	43
30,000	0.45	38
30,000	0.90	43

c. Engine Relight

Engine testing was conducted to simulate the engine starting capability 45 seconds after shutdown from cruise power. An inlet distortion screen simulating the Boeing 727 center engine inlet distortion was utilized during the test. The test was conducted as follows:

1) The desired test conditions were set with the bulkhead valve slightly open.

2) A steady state data point was recorded at cruise power.

3) While recording transient data, the engine was shut down. An attempt was made to relight 45 seconds after engine shutdown. After relight, the engine was accelerated slowly to cruise power.

4) The above procedure was repeated with variations in Mn to establish the relight envelope. Ref. Table XIII.

TABLE XIII

JT8D-109 RELIGHT CONDITIONS

Altitude (ft)	Mn	TT2 (°F)
25,000	0.40	40
25,000	0.40	46
25,000	0.90	44
25,000	0.90	43
30,000	0.45	38
30,000	0.90	43
30,000	0.90	43
30,000	0.90	50
30,000	0.90	44
40,000	0.55	35
40,000	0.55	43

2. Test Results and Discussion of Results

a. Cold Engine Airstart

The results of the JT8D-109 cold engine airstart tests are shown in Table XIV.

TABLE XIV

JT8D-109 COLD AIRSTART TEST RESULTS
(With Inlet Distortion)
TT7 – TT2 ≈ 0°F

Altitude (ft)	10000	10000	10000	10000	15000	15000	15000	15000	15000
Mach Number (Mn)	0.3	0.75	0.75	0.75	0.3	0.5	0.8	0.8	0.8
ΔTengine = (TT7 – TT2) (°F)	3	6	11	9.5	5	7	6.5	8	4
N1 Speed at Fuel Pressurization (rpm)	1035	2210	2195	2228	990	1635	2274	2295	2305
N2 Speed at Fuel Pressurization (rpm)	1800	4605	4525	4536	1665	3085	4810	4887	4875
Time to Engine Light-Off* (sec)	4.2	1.2	1.2	2.5	3.8	3.0	1.2	1.2	2.6
Maximum Fuel Flow (pph)	740	930	913	940	612	640	804	798	776
Maximum Exhaust Gas Temp. (°F)	660	333	372	298	680	367	316	285	293
Time to Idle** (sec)	34.8	10.6	12.0	10.3	21.0	33.0	11.0	12.2	13.3
N2 Speed at Idle (rpm)	6600	6920	6820	6950	4350	4970	7040	7000	6970
TT2 Inlet Temperature (°F)	30	53	51	58	9	28	53	55	61

*Timed from fuel pressurization

**Timed from fuel pressurization to N2 idle – 100 rpm

Table XV compares the JT8D-109 refan engine cold airstart test results with the results of the cold airstart tests previously conducted on JT8D-9 engines in the P&WA B-45 flying test bed. As shown, the results of the JT8D-109 cold airstart tests are consistent with typical JT8D-9 baseline experience.

TABLE XV

JT8D-109/D-9 COLD AIRSTART COMPARISON
TT7 – TT2 ≈ 0°F

Altitude (ft)	10000		10000		15000		15000		15000	
Mach Number (Mn)	0.3	0.3	0.75	0.7	0.3	0.3	0.5	0.5	0.8	0.7
JT8D Engine Model	D-109	D-9	D-109	D-9	D-109	D-9	D-109	D-9	D-109	D-9
Avg. Windmilling N2 (rpm)	1800	1570	4555	4292	1665	1635	3085	3173	4857	4177
Avg. Time to Light (sec)	4.2	5.4	1.6	6.7	3.8	5.4	3.0	5.3	1.7	6.7
Avg. Time to Idle (sec)	34.8	38.5	11.0	24.0	21.0	48.5	33.0	47.7	12.2	26.7

Figure 13 shows the JT8D-109 cold airstart envelope plotted against the JT8D-9 baseline envelope. As shown, the JT8D-109 engine is capable of cold airstarts within the JT8D-9 baseline envelope.

b. Engine Airstart

The results of the JT8D-109 engine airstart tests are shown in Table XVI.

Table XVII compares the JT8D-109 refan engine airstart test results with the results of the airstart tests previously conducted on JT8D-9 engines in the P&WA B-45 flying test bed. As shown, the results of the engine airstart tests are consistent with JT8D-9 baseline experience.

Figure 14 shows the JT8D-109 airstart envelope plotted against the JT8D-9 baseline envelope. As shown, the JT8D-109 engine is capable of airstarts within the JT8D-9 baseline envelope.

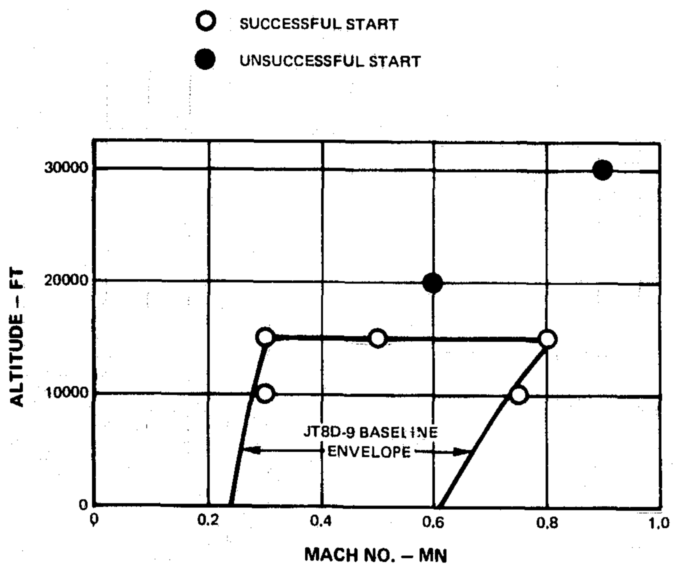


Figure 13 JT8D-109 Cold Engine Airstarts ($\Delta T \approx 0°F$)

TABLE XVI

JT8D-109 AIRSTART TEST RESULTS
(With Inlet Distortion)
$TT7 - TT2 \approx 100°F$

Altitude (ft)	20000	20000	20000	25000	25000	30000	30000
Mach Number (Mn)	0.35	0.35	0.9	0.9	0.9	0.45	0.9
ΔTengine = (TT7 – TT2) (°F)	107	100	96	100	150	100	100
N1 Speed at Fuel Pressurization (rpm)	1200	1240	2445	2390	2615	1517	2402
N2 Speed at Fuel Pressurization (rpm)	2180	2195	5520	5340	5910	2820	5240
Time to Engine Light-Off* (sec)	7.8	9.3	4.4	4.0	4.0	10.0	6.0
Maximum Fuel Flow (pph)	556	545	810	565	560	543	562
Maximum Exhaust Gas Temp. (°F)	690	640	352	405	460	810	322
Time to Idle** (sec)	41.2	28.7	31.0	23.4	17.0	30.0	37.1
N2 Speed at Idle (rpm)	3990	3340	7850+	6070	5930	3690	6990
TT2 Inlet Temperature (°F)	45	42	52	45	43	38	43

*Timed from fuel pressurization
**Timed from fuel pressurization to N2 idle – 100 rpm
+PLA positioned above idle

TABLE XVII

JT8D-109/D-9 AIRSTART COMPARISON
TT7 − TT2 ≈ 100°F

Altitude (ft)	20000		20000		30000		30000	
Mach Number (Mn)	0.35	0.3	0.9	0.76	0.45	0.4	0.9	0.9
JT8D Engine Model	D-109	D-9	D-109	D-9	D-109	D-9	D-109	D-9
Avg. Windmilling N2 (rpm)	2188	1857	5520	3300	2820	1919	5240	Not Available
Avg. Time to Light (sec)	8.6	5.2	4.4	4.9	10.0	5.6	6.0	Not Available
Avg. Time to Idle (sec)	35	46	31	58	30	38	37	Not Available

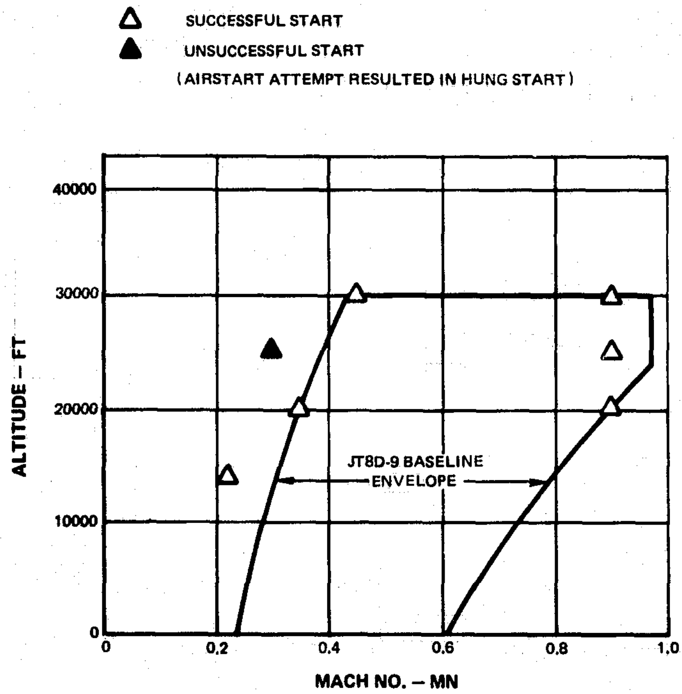


Figure 14 JT8D-109 Engine Airstarts ($\Delta T \approx 100°F$)

c. Engine Relight

The results of the JT8D-109 engine relight tests are shown in Table XVIII.

Table XIX compares the JT8D-109 refan engine relight test results with the results of the relight tests previously conducted on JT8D-9 engines in the P&WA B-45 flying test bed. The JT8D-109 test results are consistent with typical JT8D-9 baseline experience.

TABLE XVIII

JT8D-109 RELIGHT TEST RESULTS
(With Inlet Distortion)
45-SECOND SHUTDOWN

Altitude (ft)	25000	25000	25000	25000	30000	30000	30000	30000	30000	40000	40000
Mach Number (Mn)	0.4	0.4	0.9	0.9	0.45	0.9	0.9	0.9	0.9	0.55	0.55
ΔTengine = (TT7 – TT2) (°F)	305	358	180	178	400	[illegible]	220	205	142	436	470
N1 Speed at Fuel Pressurization (rpm)	1790	1580	2435	2435	1534	[illegible]	2432	2460	2375	1935	1915
N2 Speed at Fuel Pressurization (rpm)	4030	3120	5470	5450	3350	5460	5465	5490	5300	4610	4420
Time to Engine Light-off* (sec)	3.0	4.0	3.0	3.5	5.0	6.0	9.0	4.0	8.0	7.5	5.5
Maximum Fuel Flow (pph)	560	554	605	597	555	560	550	575	555	556	553
Maximum Exhaust Gas Temp. (°F)	650	720	372	355	865	484	476	480	285	920	420
Time to Idle** (sec)	22.1	21.6	24.0	27.5	18.6	20.4	24.8	21.0	28.0	20.9	25.3
N2 Speed at Idle (rpm)	5300	4940	6680	6460	3890	6790	7210+	6740	6530	5360	6230
TT2 Inlet Temperature (°F)	40	46	44	43	38	43	43	50	44	35	43

*Timed from fuel pressurization
**Timed from fuel pressurization to N2 idle – 100 rpm
+PLA positioned above idle

TABLE XIX

JT8D-109/D-9 RELIGHT COMPARISON
45-SECOND SHUTDOWN

Altitude (ft)	25000	25000	30000	30000	40000	
Mach Number (Mn)	0.4	0.9	0.45	0.9	0.55	0.55
JT8D Engine Model	D-109	D-109	D-109	D-109	D-109	D-9
Avg. Windmilling N2 (rpm)	3575	5460	3350	5429	4515	3767
Avg. Time to Light (sec)	3.5	3.3	5.0	6.7	6.5	6.5
Avg. Time to Idle (sec)	21.8	25.8	18.6	23.6	23.1	43

Figure 15 shows the JT8D-109 relight envelope plotted against the JT8D-9 baseline envelope.

The results of the flight starting tests conducted on the JT8D-109 refan engine are consistent with typical JT8D-9 experience. The capability of the JT8D-109 engine to successfully perform flight starts within the current JT8D-9 flight start envelope was demonstrated by flight start testing.

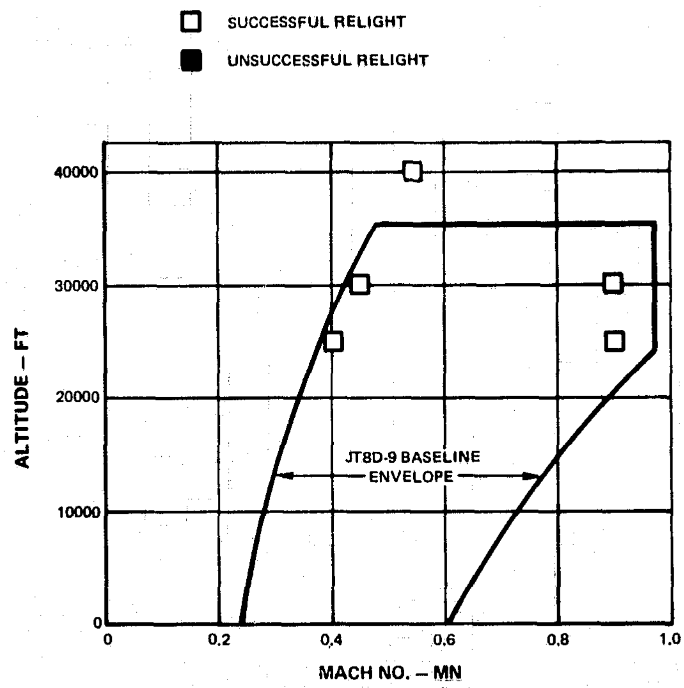


Figure 15 JT8D-109 Engine Relights (45 sec shutdown)

C. OFF-IDLE SURGE TESTS

Engine surge margin tests were conducted to determine the JT8D-109 transient stability margin in the off-idle power region. A surge was identified by an audible thump, a jump in turbine cooling air pressure or burner pressure, hesitation in N2 speed, and/or torching in the engine tailpipe.

1. Test Procedures

For these tests, a special "flat ratio" fuel control was installed. This control was a standard fuel control modified to permit the engine to run on a constant ratio acceleration schedule as a tool to define HPC off-idle surge characteristics (surge bucket). The standard fuel control senses TT2 in the engine; the flat ratio control had a modified temperature sensing servo assembly that was actuated by externally supplied nitrogen pressure. By setting a specific nitrogen pressure, the control produced a constant acceleration schedule of fuel flow/burner pressure ratio (Wf/Pb). Changing the nitrogen pressure changed the schedule ratio.

A Hamilton Standard Model GS 7800 ratio plotter was utilized during the test. The ratio plotter is a self contained unit which is capable of plotting fuel flow/burner pressure (Wf/Pb) versus N2 speed (X-Y plot). A special fuel flow meter, N2 tachometer, and burner pressure transducer were installed on the engine to supply the necessary input signals to the ratio plotter.

The following procedure was used:

The engine was started and trimmed to 5000 rpm N2, and a steady state calibration performed at 5000, 6000, 7000, and 8000 rpm N2 to calibrate the ratio plotter. After this four-point calibration was completed, the X-Y plot of the fuel flow/burner pressure versus N2 speed was initiated.

For plotting the left side of the surge region, a reference stabilized starting speed of 5000 ± 100 rpm N2 was established, and nitrogen pressure set to provide an acceleration schedule equivalent to 55 to 60 ratios fuel flow/burner pressure. A snap acceleration was made. The power was reduced when the first surge occurred, or at 8000 rpm N2 if no surge was encountered.

Nitrogen pressure was raised in 5 psig steps, lowering the acceleration schedule until surge-free operation was achieved. Changes in nitrogen pressure were always made in an increasing direction. Reduction and reset of nitrogen pressure were made as required by test conditions.

When surge-free operation had been achieved under these conditions, the last surge point defined was repeated, and additional accelerations were made, raising the nitrogen pressure level in one psig increments until surge-free operation was again achieved for three consecutive accelerations.

This procedure defined the left side boundary of the surge bucket and partially defined the bottom.

In plotting the right side boundary of the surge bucket, the nitrogen level was initially set to obtain 46 ratios. Snap accelerations were made at several points (± 100 rpm, higher and lower than the apparent minimum bucket). The nitrogen pressure was then lowered (4-5 psig) and these speeds repeated.

This procedure was repeated until the right side of the curve bucket was defined. If surges were encountered further to the right, speeds were increased until maximum ratios were obtained with maximum speed, and surge-free operation was achieved.

Figure 16 presents a typical JT8D-109 off-idle surge margin test sequence.

2. Results and Discussion of Results

A summary of results from the off-idle surge margin tests conducted on engines EE-1, EE-2 and EE-3 in the baseline JT8D-9 and refan JT8D-109 configurations is presented in Table XX.

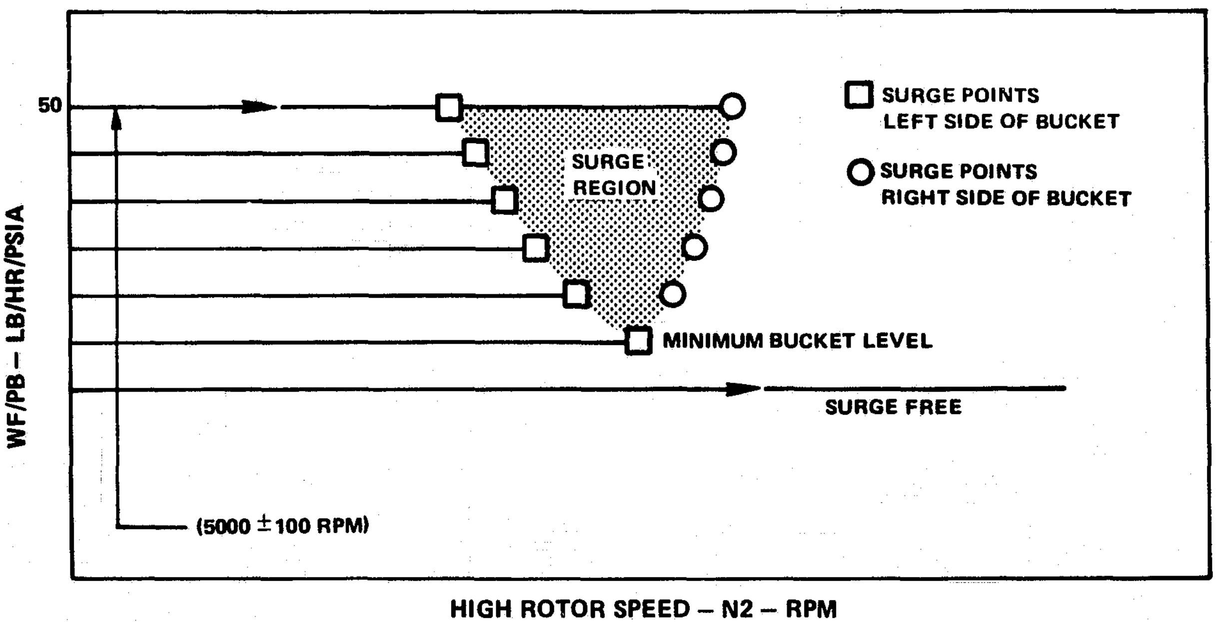


Figure 16 Typical JT8D-109 Off-Idle Surge Margin Test Sequence

TABLE XX

JT8D-9/D-109 MINIMUM OFF-IDLE SURGE LEVEL

	WF/PB ~ LB/HR/PSIA	
Engine	JT8D-9	JT8D-109
EE-1	52.0	52.0
EE-2	50.0	49.9
EE-3	46.8	46.1

Figures 17, 18 and 19 present comparisons of the baseline JT8D-9 and refan JT8D-109 engine off-idle surge minimum levels for engines EE-1, EE-2 and EE-3. The minimum surge bucket level for the JT8D-109 configuration is essentially the same as that of the JT8D-9 configuration. The right hand side of the surge bucket, which is the most significant side for tailoring an acceleration schedule, was also determined to be essentially the same as the JT8D-9 configuration.

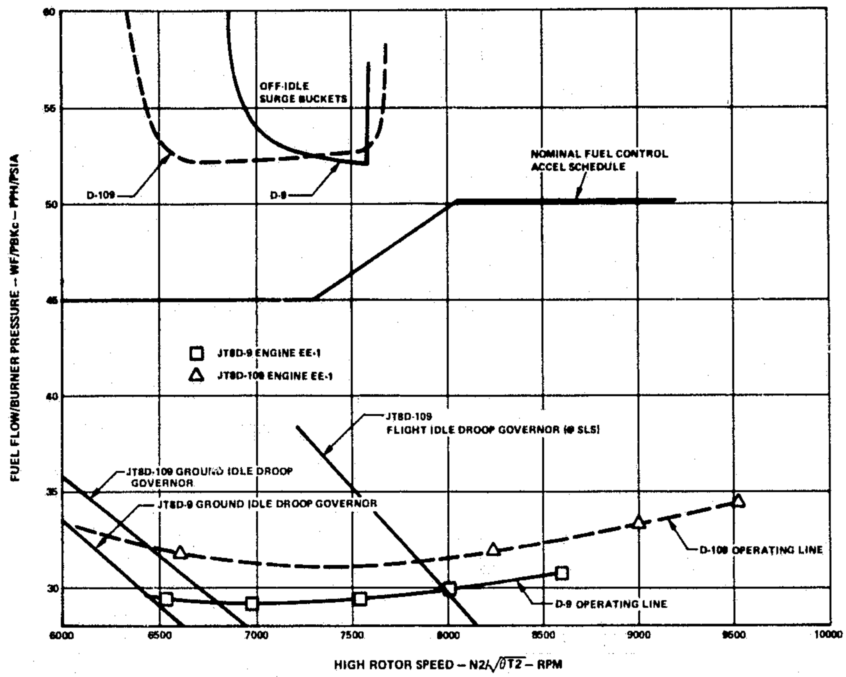


Figure 17 JT8D-109/D-9 Engine EE-1 Off-Idle Surge Margin

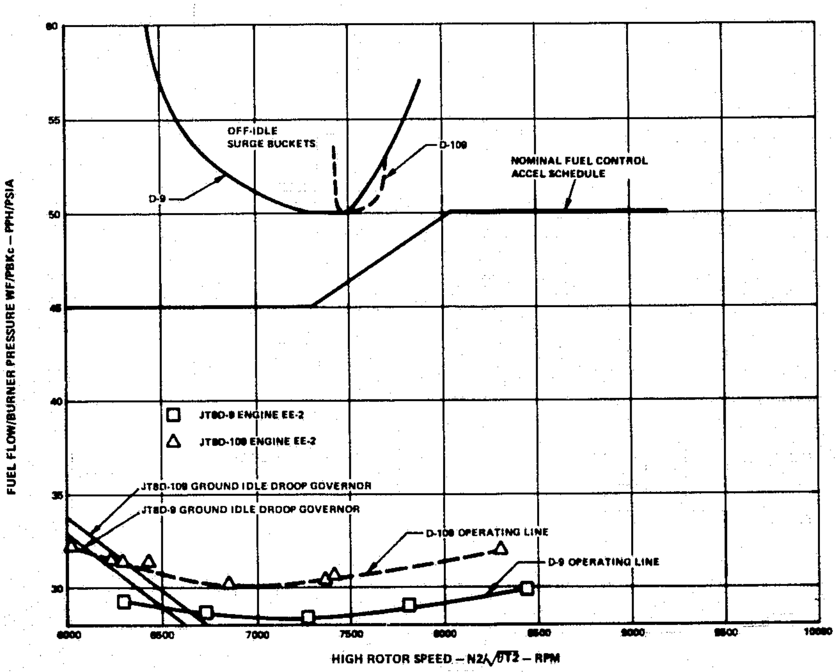


Figure 18 JT8D-109/D-9 Engine EE-2 Off-Idle Surge Margin

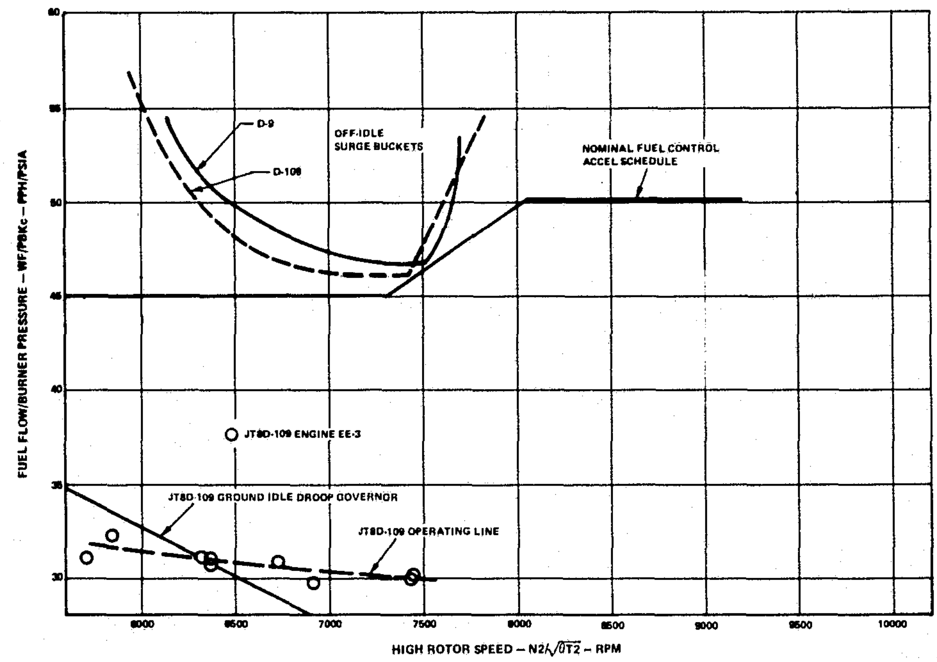


Figure 19 JT8D-109/D-9 Engine EE-3 Off-Idle Surge Margin

D. INLET DISTORTION TESTS

JT8D-109 engines EE-1 and EE-2 and the fan/LPC rig were run with inlet distortion screens simulating critical inlet patterns defined from inlet scale model tests to determine the tolerance of the JT8D-100 compressor system to inlet distortion. The testing of EE-3 at the NASA-LeRC facility included the use of an inlet distortion screen, shown in Figure 27, to simulate the 727 center engine distortion. This testing is reported in Section V. F. In addition, distortion effects of the Douglas DC-9 flight inlet on the JT8D-109 engine were determined during sea level static testing.

1. Fan/LPC Rig Inlet Distortion Test Procedures

Six inlet distortion patterns were tested. Three "classical" screens, I.D. radial, O.D. radial, and 180° full span circumferential, were selected to allow comparison of the distortion sensitivity of the compression system to previous experience. These screens are shown schematically in Figure 20. The I.D. screen installed in the inlet is shown in Figure 21. The classical screens were designed to produce distortion levels at least 10 percent in excess of the limiting total pressure variations at the engine face as shown in Figures 22 and 23.

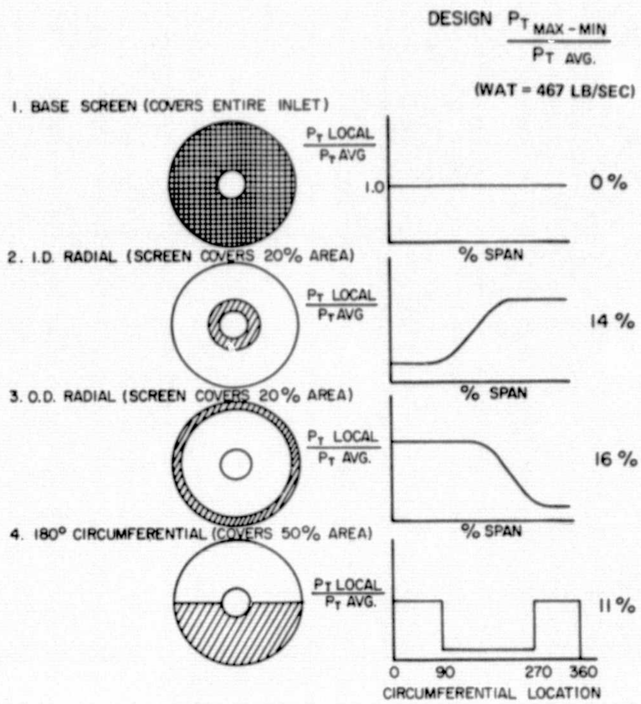


Figure 20 JT8D-109 Classical Engine Inlet Screen Patterns and Predicted Distortion Levels

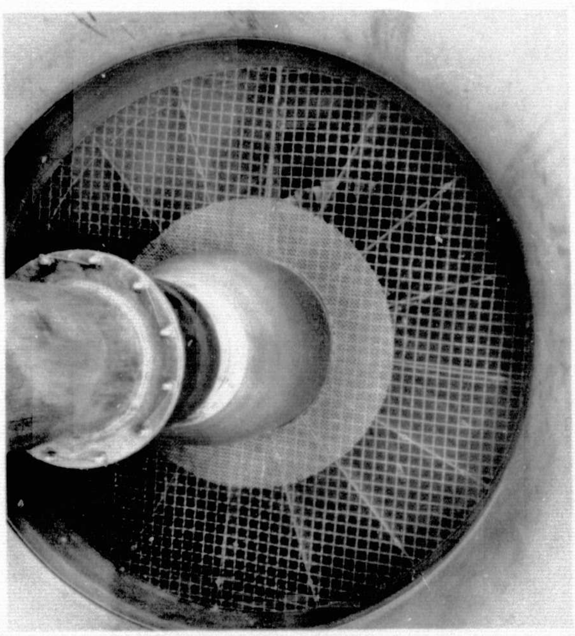


Figure 21 JT8D-109 Fan/Low Compressor I. D. Radial Inlet Distortion Screen (X-40950)

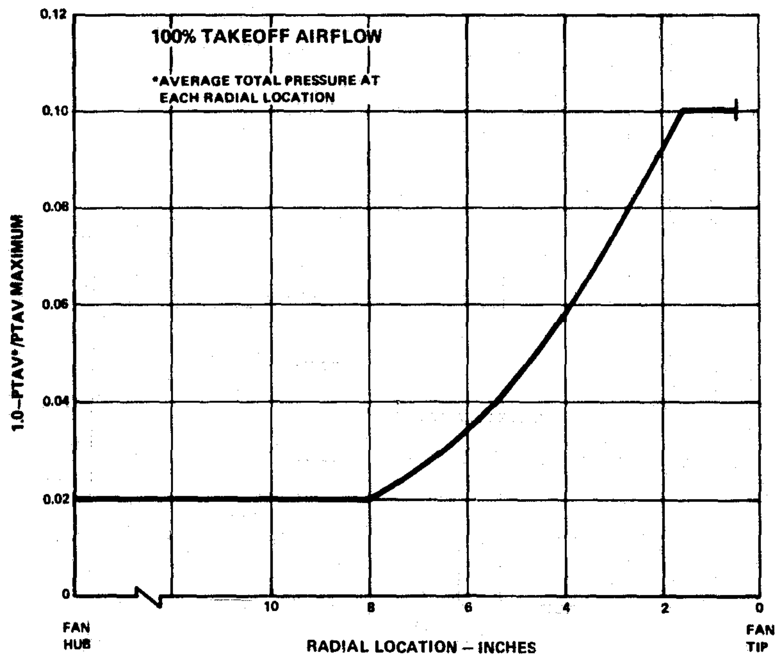


Figure 22 JT8D-109 Limiting Radial Total Pressure Variation at Engine Face

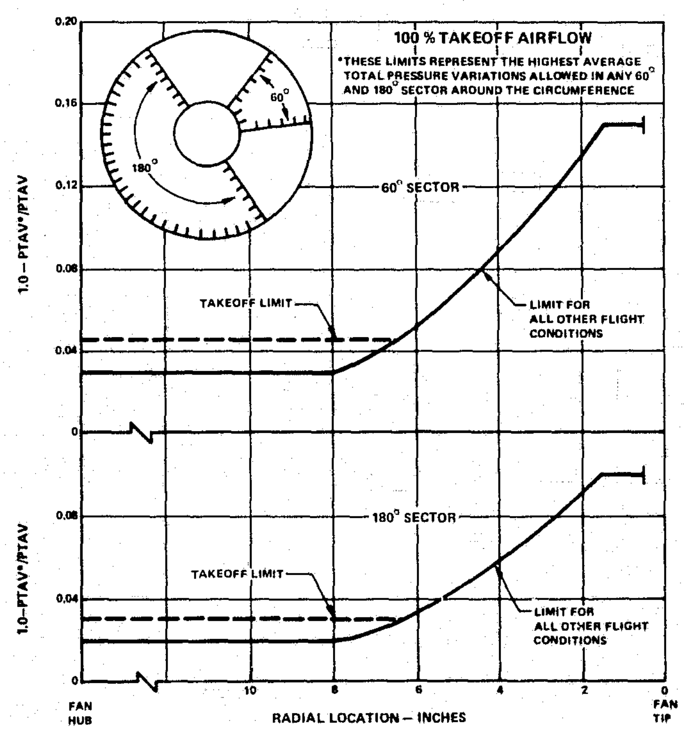
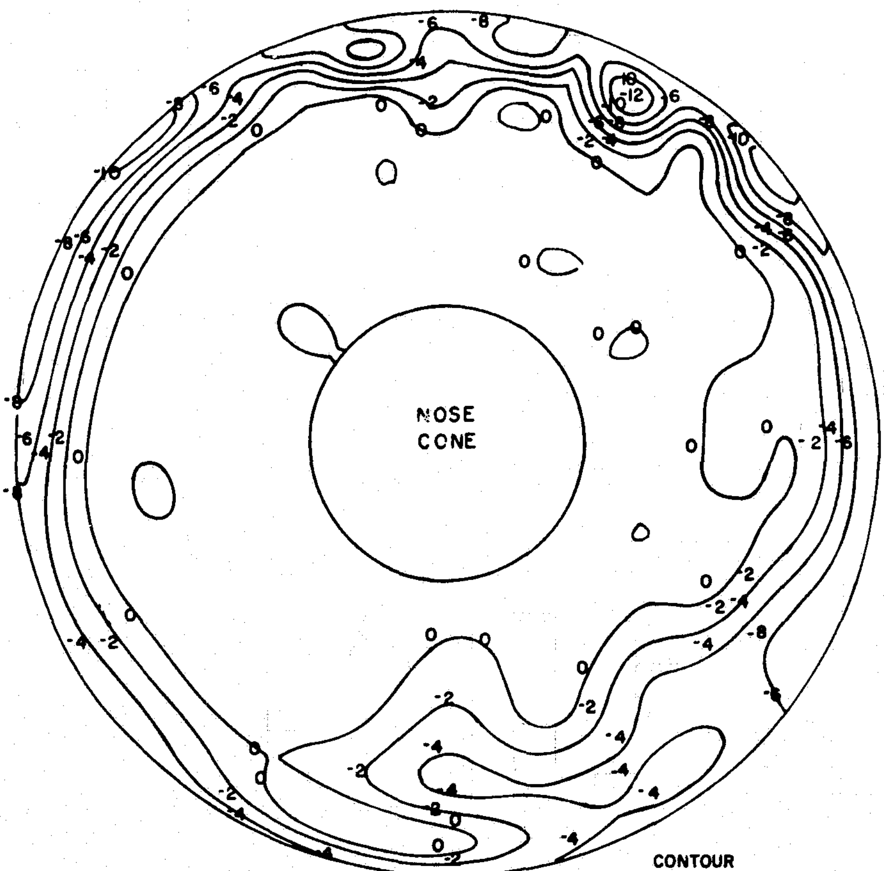


Figure 23 JT8D-109 Limiting Circumferential Total Pressure Variation at Engine Face

Three flight screen patterns were selected from Boeing inlet model test data to be representative of conditions expected to be encountered in actual service of the refanned 727 aircraft. The patterns represent the engine running at sea level static take-off power in the 1) center engine location with no crosswind, 2) center engine location with a 35 knot crosswind, and 3) pod engine location with a 30 knot crosswind. Model data pressure contours are shown in Figures 24, 25 and 26. The pressure patterns listed in the figures have been intensified, utilizing RMS readings of high response pressure measurements obtained during model steady state testing to reflect the effects of inlet turbulence. Figures 27, 28 and 29 show the flight screens installed in the rig inlet.



CONTOUR LINE	$P_{T\,LOCAL}/P_{TA}$
0	1.014
-2	.994
-4	.974
-6	.953
-8	.933
-10	.913
-12	.893

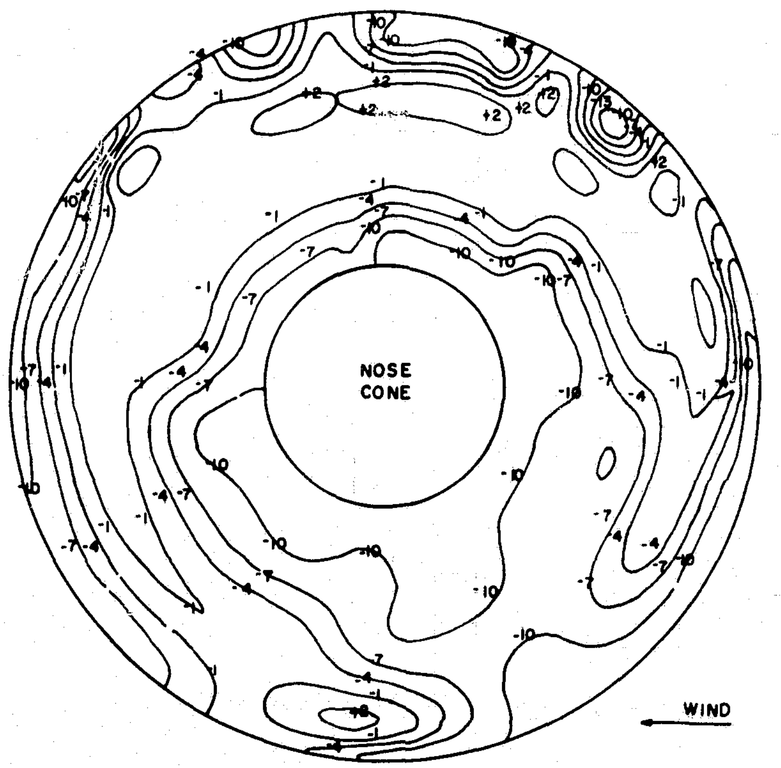
VIEW LOOKING AFT

Figure 24 Sea Level Static Inlet Distortion Pattern – 727 Center Engine at Takeoff Power

To determine the inlet total pressure patterns, the inlet distortion screens were rotated with respect to the fixed pressure instrumentation. Data points were taken at eleven screen rotational positions, for each screen, at both nominal operating line and near surge, and the results were used to determine the true average conditions at major calculating stations.

Fan constant corrected speed lines were generated by setting the fan and low pressure compressor on their nominal operating line. The primary or engine discharge valve was kept at a position to maintain the nominal low pressure compressor operating line. The fan discharge valve was then opened to obtain data below the fan operating line and closed to obtain data above the fan operating line level. Data points were recorded at successively higher fan pressure ratios and/or lower total inlet flow until verge of surge was defined. When surge was encountered, the fan discharge valve was opened and speed reduced to idle, to restore stable operation.

LPC speed lines were run in the same manner except that the fan operating line was held constant, and the primary or engine discharge valve was used to vary LPC back pressure.



VIEW LOOKING AFT

CONTOUR LINE	$P_{T\,LOCAL}/P_{T\,A}$
+2	1.070
-1	1.039
-4	1.007
-7	.976
-10	.944
-13	.913

Figure 25 35-Knot Crosswind Inlet Distortion Pattern – 727 Center Engine at Sea Level Takeoff Power

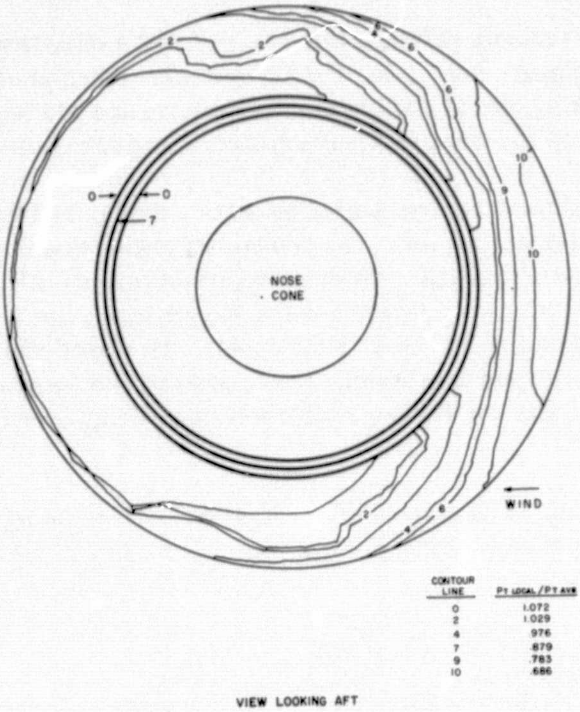


Figure 26 30-Knot Crosswind Inlet Distortion Pattern – 727 Pod Engine at Sea Level Takeoff Power

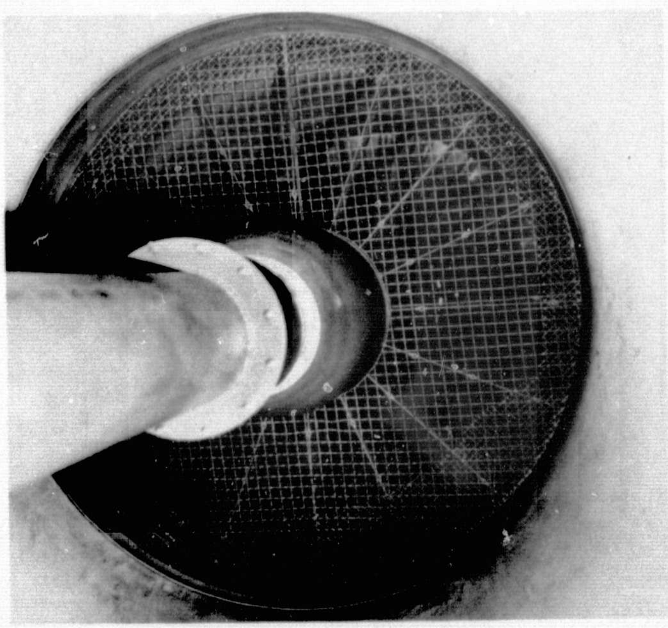


Figure 27 JT8D-109 Fan/Low Compressor 727 Center Engine Sea Level Static Inlet Distortion Screen (No Crosswind) (X-40944)

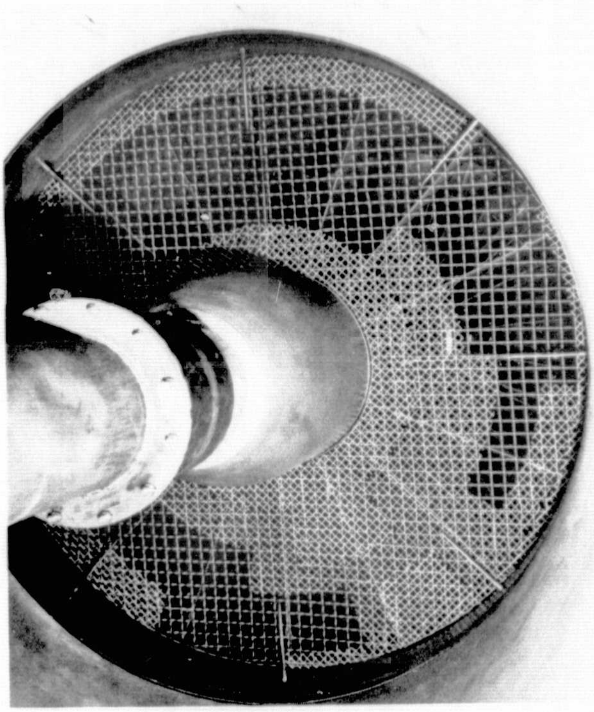


Figure 28 JT8D-109 Fan/Low Compressor 727 Center Engine Sea Level Static Inlet Distortion Screen (35-Knot Crosswind) (X-41110)

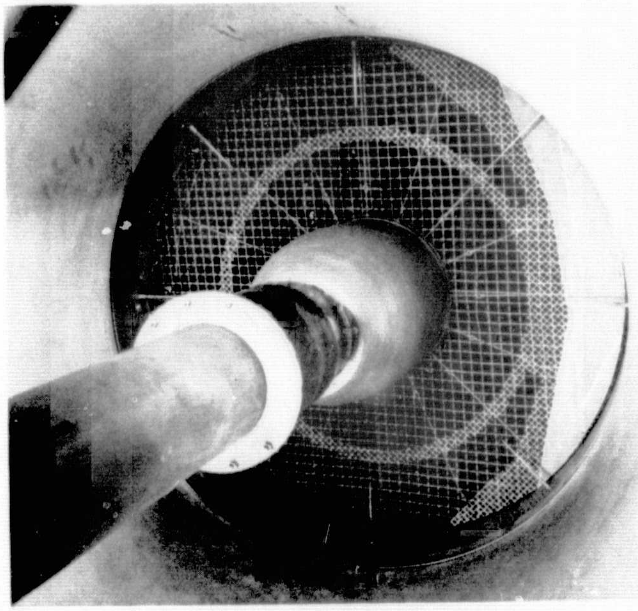


Figure 29 JT8D-109 Fan/Low Compressor 727 Pod Engine Sea Level Static Inlet Distortion Screen (30-Knot Crosswind) (XPN-45591)

Occurrence of surge operation was determined from wall statics in the fan and LPC discharge ducts. Each static was fed to the two ports of a differential pressure transducer. One port had a snubber and the other was unrestricted. At steady state operating conditions both ports read the same, but at surge the snubber resulted in different levels in the two ports.

2. Fan/LPC Rig Test Results and Discussion of Results

a. Fan Surge Margin

Positive fan surge margin was attained with all inlet distortion patterns tested. The 30-knot crosswind pod engine distortion pattern yielded the largest surge margin loss. Surge margin increased with I.D. distortion and was slightly reduced by 180° circumferential distortion. These effects of distortion on surge margin were consistent with other single stage fan experience. Fan surge margins with distorted inlet flow are summarized in Figure 30. Table XXI, taken from Figure 30, presents fan surge margins at two flows representing high and part speed operation, and presents the loss or gain in surge margin relative to the base grate surge margin at that flow. Fan sensitivity to distortion was similar to NASA single stage fan experience. Figure 31 presents the JT8D-109 fan sensitivities to I.D. radial, O.D. radial, and 180° circumferential screens as compared to other single stage fans.

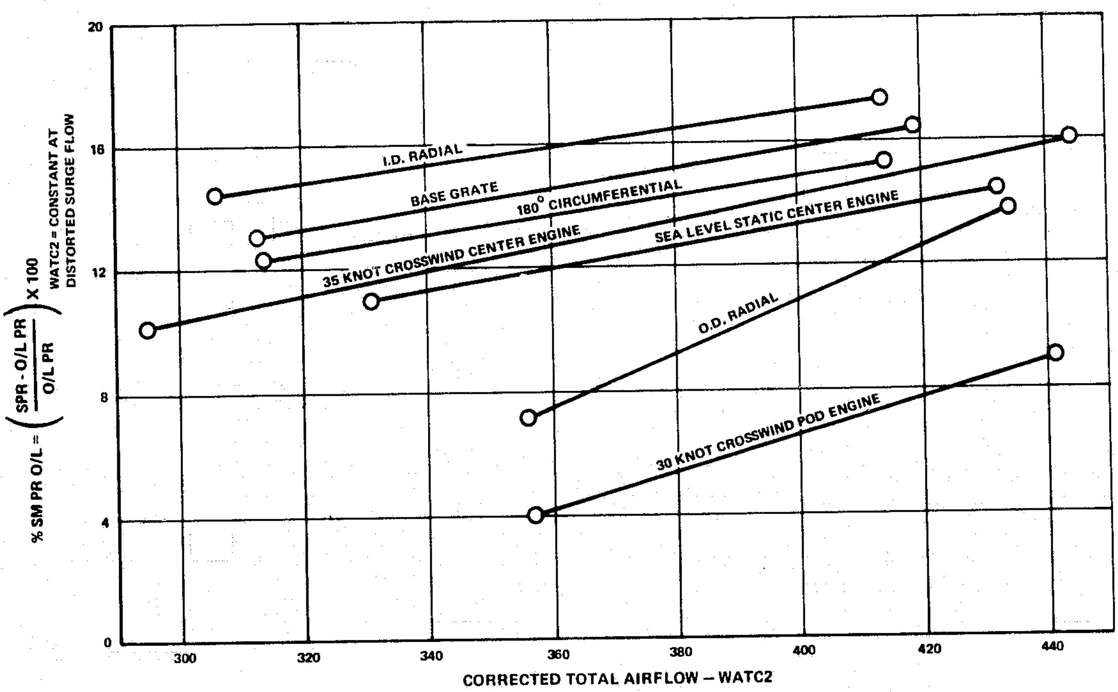


Figure 30 JT8D-109 Fan Surge Margin (2.4 OD/2) with Distorted Inlet Flow

TABLE XXI

JT8D-109 FAN SURGE MARGIN (2.4 O.D./2)

	Inlet Total Flow = 420 lb/sec		Inlet Total Flow = 320 lb/sec	
Inlet Screen	Surge Margin (%)	Δ Surge Margin (%)	Surge Margin (%)	Δ Surge Margin (%)
Clean Inlet	16.4	0	13.2	0
I.D. Radial	17.5	+1.1	15.0	+ 1.8
O.D. Radial	12.6	-3.8	4.0	- 9.2
180° Circum.	15.5	-0.9	12.6	-0.6
Sea Level Static Center	14.0	-2.4	10.6	- 2.6
35 kt. X-wind Center	15.0	-1.4	11.1	- 2.1
30 kt. X-wind Pod	7.7	-8.7	1.7	-11.5

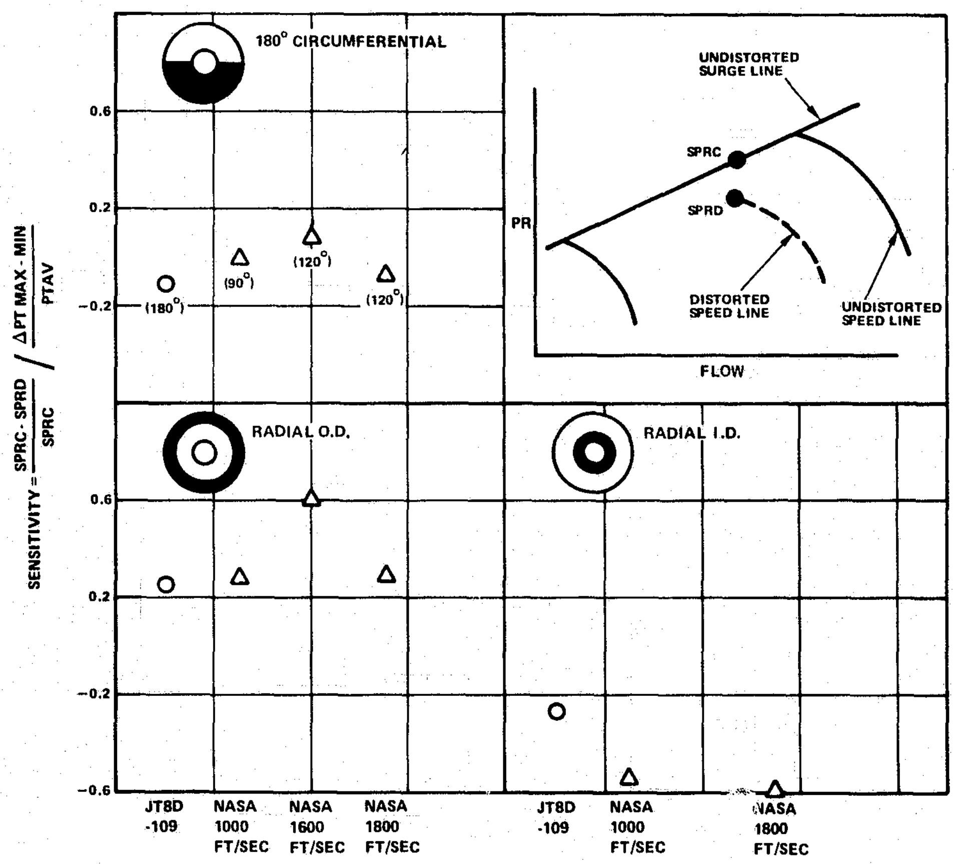


Figure 31 JT8D-109 Fan High-Speed Sensitivity Compared to Other Single-Stage Fans

b. LPC Surge Margin

Positive LPC surge margin was attained with all inlet distortion patterns tested. The LPC showed the largest surge margin loss with 180° circumferential distortion, which was consistent with previous experience. LPC surge margins, with distorted inlet, are summarized in Figure 32. Table XXII, taken from Figure 32, presents LPC surge margins at two flows representing high and part speed operation, and presents the loss or gain in surge margin relative to the base grate at that flow. LPC sensitivity agrees with previous P&WA experience. Figure 33 presents the JT8D-109 LPC sensitivity to 180° circumferential as compared to other compressors.

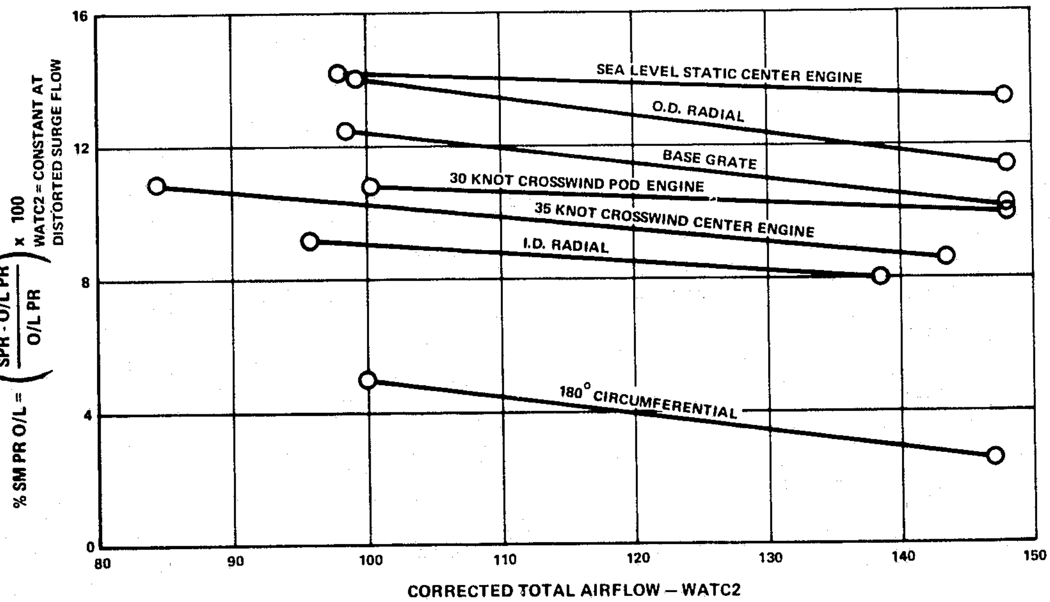


Figure 32 JT8D-109 Low-Pressure Compressor Surge Margin (3/2) with Distorted Inlet Flow

TABLE XXII

JT8D-109 LPC SURGE MARGIN (3/2)

	LPC Flow = 148 lb/sec		LPC Flow = 98 lb/sec	
Inlet Screen	Surge Margin (%)	Δ Surge Margin (%)	Surge Margin (%)	ΔSurge Margin (%)
Clean Inlet	10.1	0	12.5	0
I.D. Radial	7.8	-2.3	9.1	-3.4
O.D. Radial	11.4	+1.3	14.2	+1.7
180° Circum.	2.4	-7.7	5.1	-7.4
Sea Level Static Center	13.4	+3.3	14.2	+1.7
35 kt X-wind Center	8.4	-1.7	10.4	-2.1
30 kt X-wind Pod	9.9	-0.2	10.9	-1.6

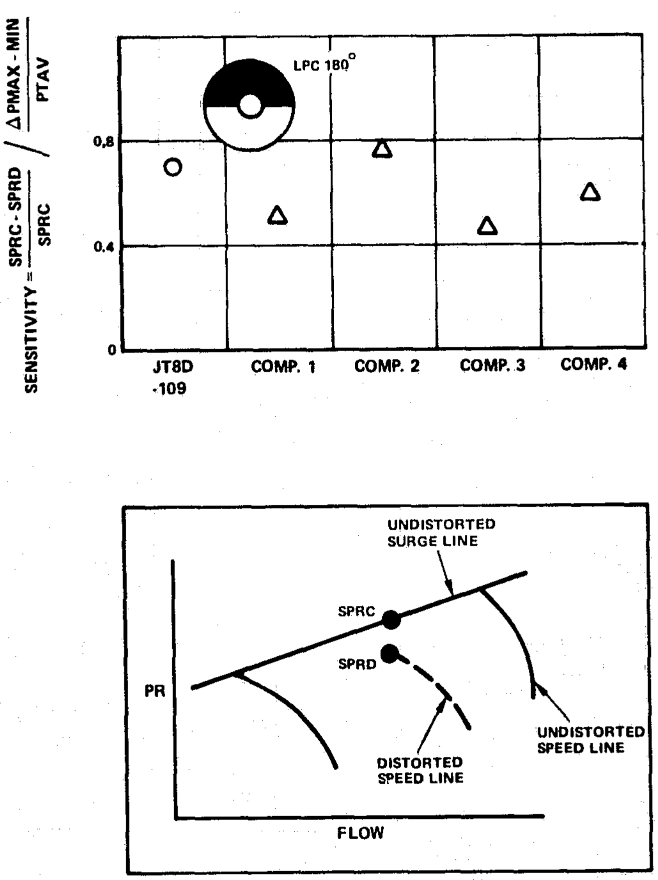


Figure 33 JT8D-109 Low-Pressure Compressor High-Speed Sensitivity Compared to Other Compressors

3. Engine Inlet Distortion Test Procedure

JT8D-109 engine inlet distortion testing was conducted with the same inlet distortion screens used during the fan/LPC rig test program to simulate the following conditions:

1) Sea level static pattern – 727 center inlet duct at takeoff airflow.

2) 35-knot crosswind pattern – 727 center inlet duct at takeoff airflow.

3) 30-knot crosswind pattern – 727 pod inlet at takeoff airflow.

The above inlet pressure patterns are shown in Figures 24, 25 and 26, respectively, and the respective inlet distortion screens are illustrated in Figures 27, 28 and 29.

The following test procedure was followed for the engine testing with each distortion screen:

1) A performance calibration was conducted at the following points: idle, 5000, 9000, 13000, and 16600 lbs corrected thrust.

2) With the full span PT2 rakes removed, two slow accelerations and decelerations from idle to take-off and from take-off to idle were performed.

3) Two snap accelerations and decelerations from idle to take-off and from take-off to idle were also performed.

4. Engine Inlet Distortion Test Results and Discussion of Results

JT8D-109 refan engine EE-1 was tested at sea level static conditions with and without the above inlet distortion screens installed to demonstrate D-109 engine stability with a clean inlet and with flight distortion patterns. With a clean inlet and with each distortion screen installed, a slow acceleration and a slow deceleration were performed between idle and 8000 rpm N1 or maximum EGT (TT7 = 1020°F). The test conditions are shown in Table XXIII. Stable engine operation existed at all test conditions.

TABLE XXIII

JT8D-109 ENGINE EE-1 INLET DISTORTION TEST
SLOW ACCELERATION TO MAXIMUM CONDITION
Aj = 8.33 sq. ft.

Inlet Screen	Max. EGT TT7 (°F)	Max. Corr. N1 $N1/\sqrt{\theta T2}$ (rpm)
Clean Inlet	1020	7676
Sea Level Static Center	1020	7453
35 kt. X-wind Center	1020	7274
30 kt. X-wind Pod	1020	7296

5. DC-9 Flight Inlet Distortion Test Procedure

A sea level static engine performance calibration was conducted on JT8D-109 engine EE-2 with the DC-9 flight inlet installed. Eight full span PT2 rakes, with 10 pressure sensing elements per rake, were installed aft of the flight inlet. In addition, four 10-element boundary rakes were installed equally spaced circumferentially and in the same axial plane as the PT2 rakes.

6. DC-9 Flight Inlet Test Results and Discussion of Results

Three typical DC-9 inlet distortion patterns are shown in Figures 34, 35 and 36 for 100%, 75%, and 50% take-off airflow, respectively. The isobars in these figures represent the percent loss in total pressure from ambient. The relatively low pressure region near the O.D. wall, seen in Figure 34, was thought to be the result of wind across the inlet.

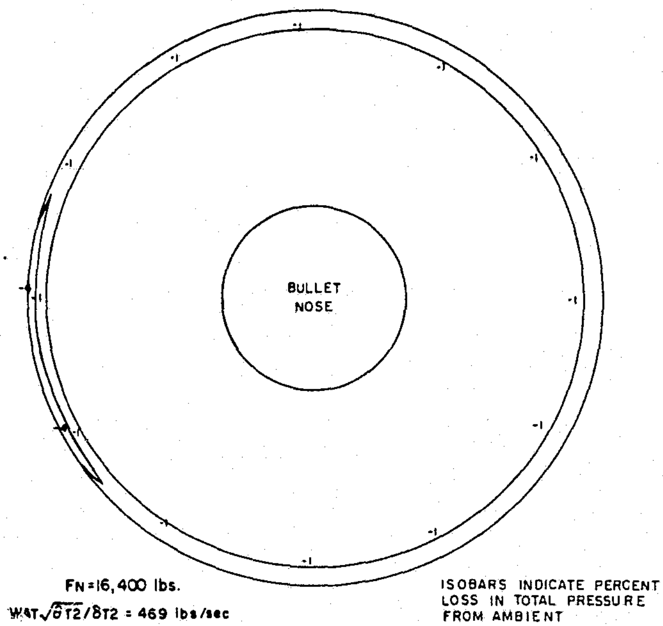


Figure 34 JT8D-109 Engine EE-2 Inlet Distortion Pattern with DC-9 Inlet Installed

Figures 37, 38 and 39 show the ring average inlet recovery as a function of radial location for the same points as Figures 34 through 36. These plots indicate that the lowest ring average pressure levels experienced in the inlet are: 3.5% below ambient for take-off flow, 2% for 75% flow and 1% at 50% flow (exclusive of the area within ½ inch of the O.D. wall). These plots, Figures 37, 38 and 39, also indicate decreasing boundary layer thickness at reduced flow.

Figure 40 shows the face average inlet recovery, PT2 avg/Pamb, over a wide range of power levels. Recovery was 99.5% at take-off flow and improved at lower flow.

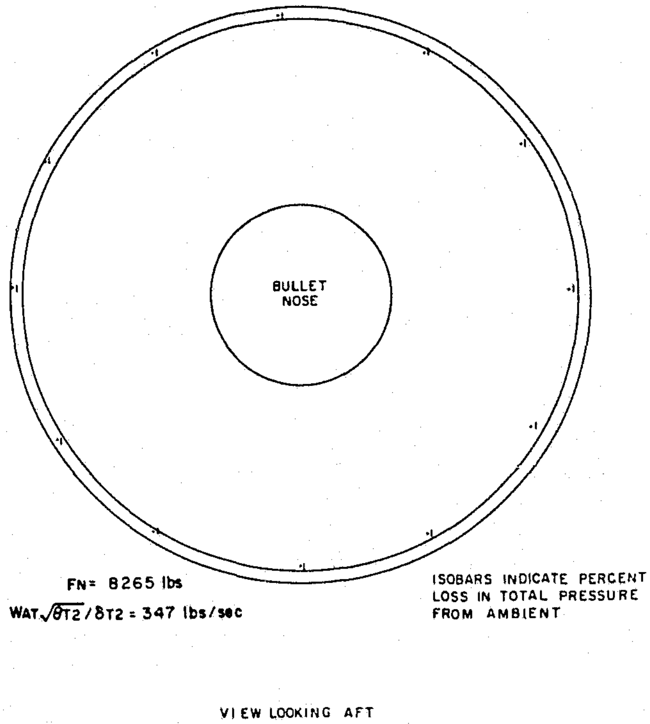


Figure 35 JT8D-109 Engine EE-2 Inlet Distortion Pattern with DC-9 Inlet Installed

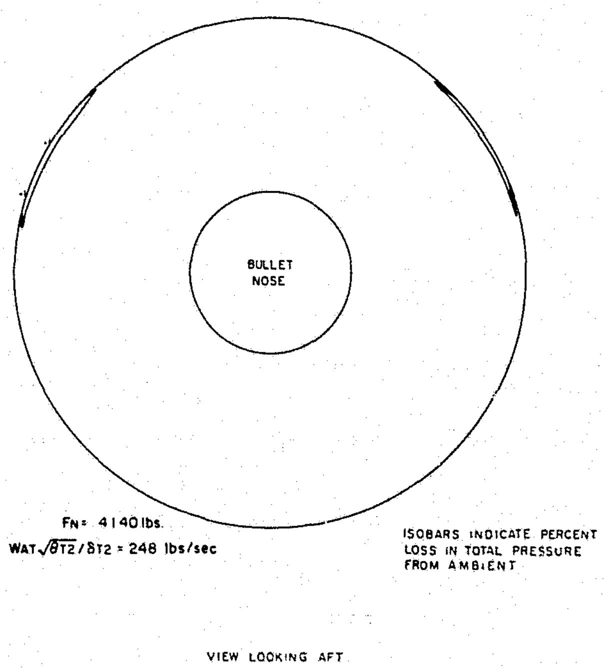


Figure 36 JT8D-109 Engine EE-2 Inlet Distortion Pattern with DC-9 Inlet Installed

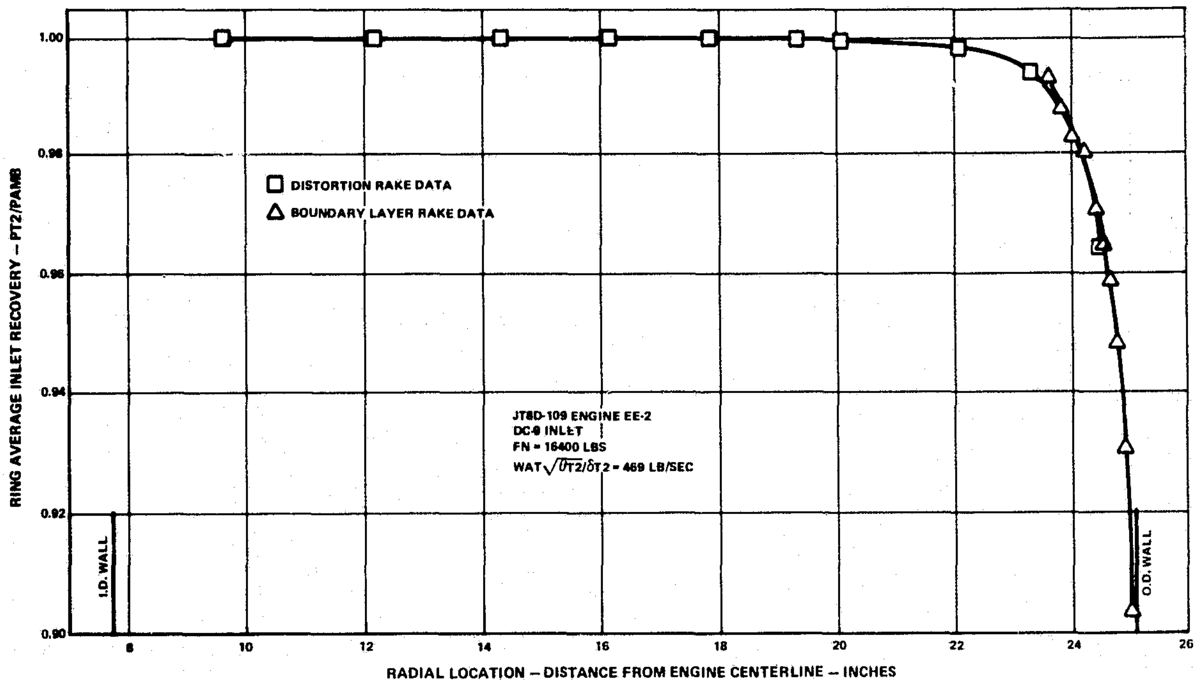


Figure 37 JT8D-109 Ring Average Inlet Recovery – DC-9 Inlet

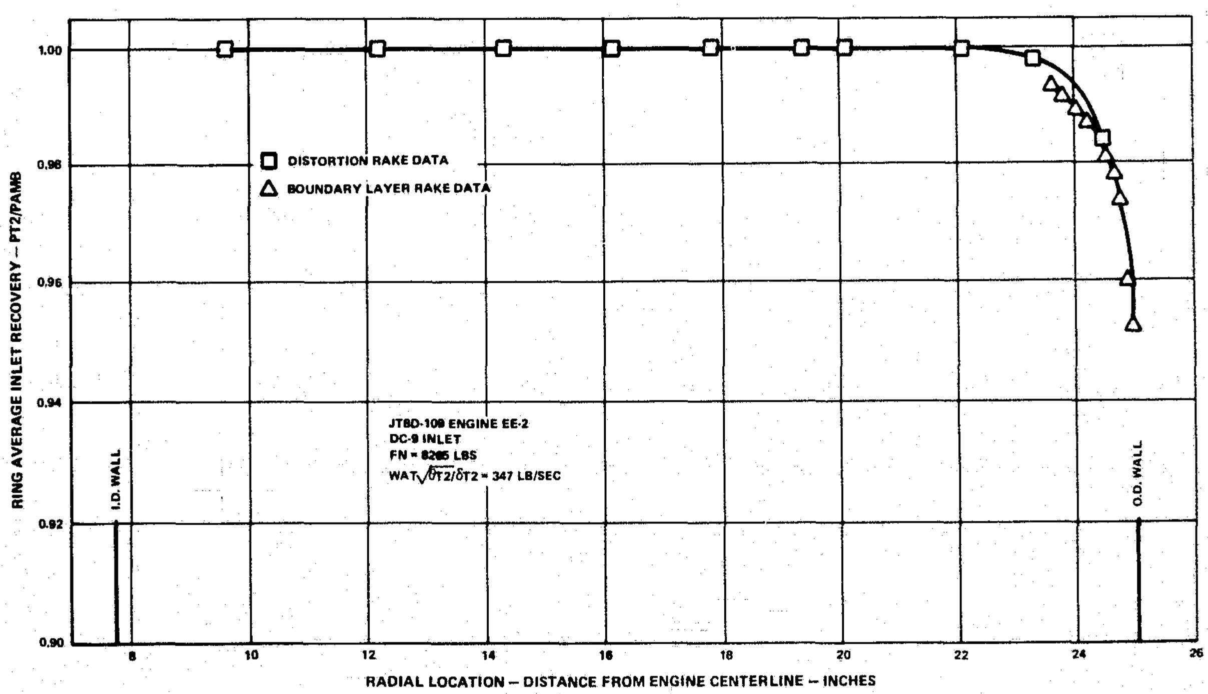


Figure 38 JT8D-109 Ring Average Inlet Recovery – DC-9 Inlet

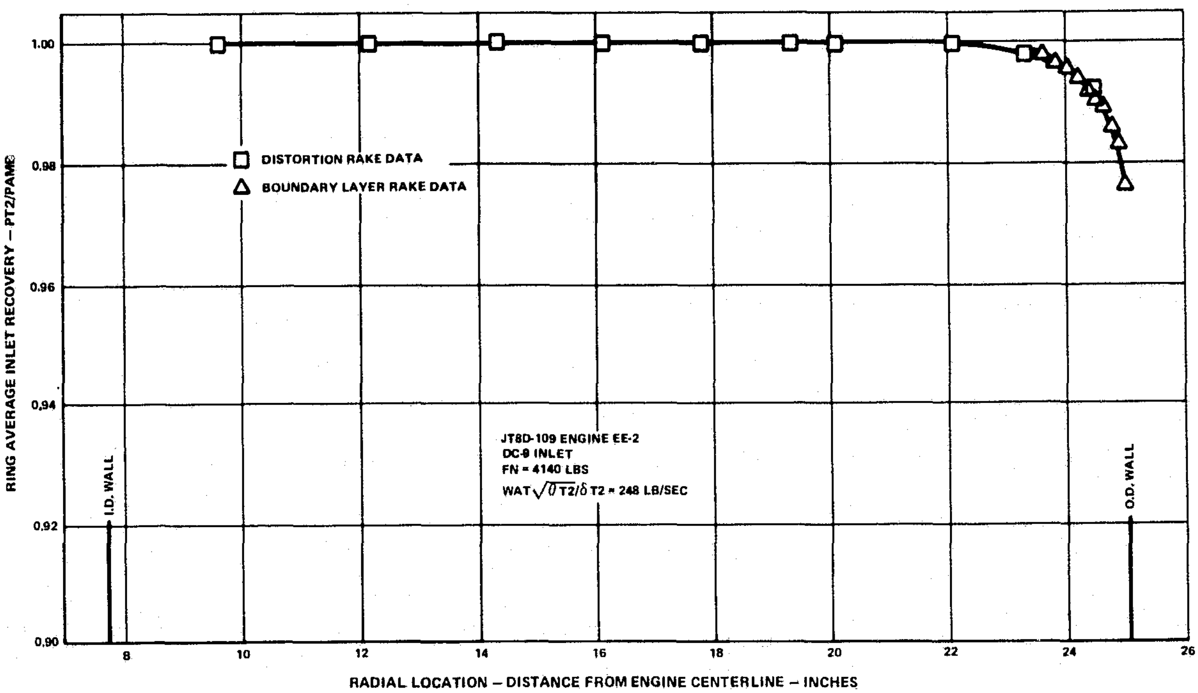


Figure 39 JT8D-109 Ring Average Inlet Recovery – DC-9 Inlet

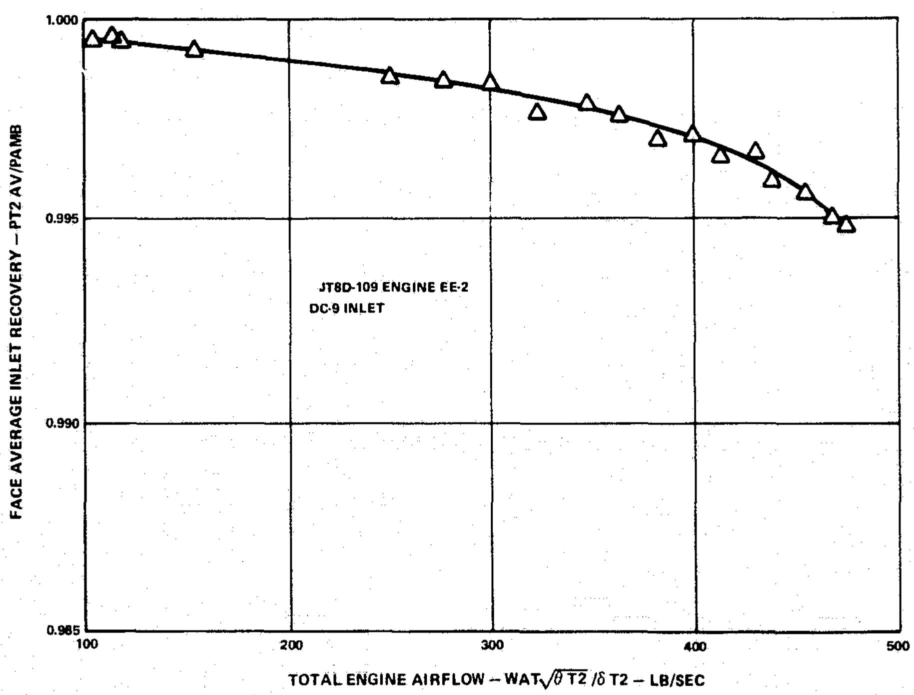


Figure 40 JT8D-109 Face Average Inlet Recovery – DC-9 Inlet

E. ACCELERATION RESPONSE TESTS

JT8D-109 engine acceleration response characteristics were determined during sea level testing of engines EE-1, EE-2 and EE-3. Additional testing was conducted at the NASA LeRC altitude test facility on EE-3 and during the DC-9 flight test program.

1. Test Procedure

Acceleration response tests were conducted on EE-1, EE-2 and EE-3. The following procedure was used:

Timed accelerations from idle to takeoff corrected thrust were performed over the idle N2 speed range of 6000 to 9000 rpm.

The engines were set to takeoff corrected thrust and the N2 rpm recorded at this thrust. A response timer was set at 99% of this N2 rpm. The engines were reset to the desired idle N2 speed and stabilized for five minutes, after which the steady state operating point was recorded.

An oscillograph was then started, and a snap acceleration made from idle to maximum power lever angle. When the observed N2 rpm reached the preset response timer speed, the power lever was retarded to maintain this N2 rpm. The oscillograph was stopped and a full reading taken. The oscillograph recording included high rotor speed, low rotor speed, power lever angle, fuel flow, burner pressure, low pressure compressor static exit pressure, and high pressure compressor static exit pressure.

The engines were stabilized for five minutes, after which the steady state operating point was recorded.

In addition to the above tests, acceleration response characteristics with engine airbleed were determined on engines EE-2 and EE-3. Engine 13th stage airbleed amounts of up to 8% of primary airflow were tested.

2. Test Results and Discussion of Results

Table XXIV compares the acceleration response characteristics of the JT8D-9 and JT8D-109 engines at sea level static conditions. As shown, the average D-109 engine accelerates from idle to takeoff about 2.9 seconds slower than the D-9 engine. The slower acceleration characteristics of the D-109 are attributable to a 40 percent increase in the low rotor polar moment of inertia relative to that of the baseline D-9 engine and to a two Wf/Pb ratio increase in the operating line relative to the D-9, as indicated in Figures 17 and 18. Figure 41 shows the JT8D-9 and D-109 acceleration times vs. corrected high-rotor speed characteristics for no service bleed and for 4 percent and 8 percent 13th-stage service bleed at sea level static conditions.

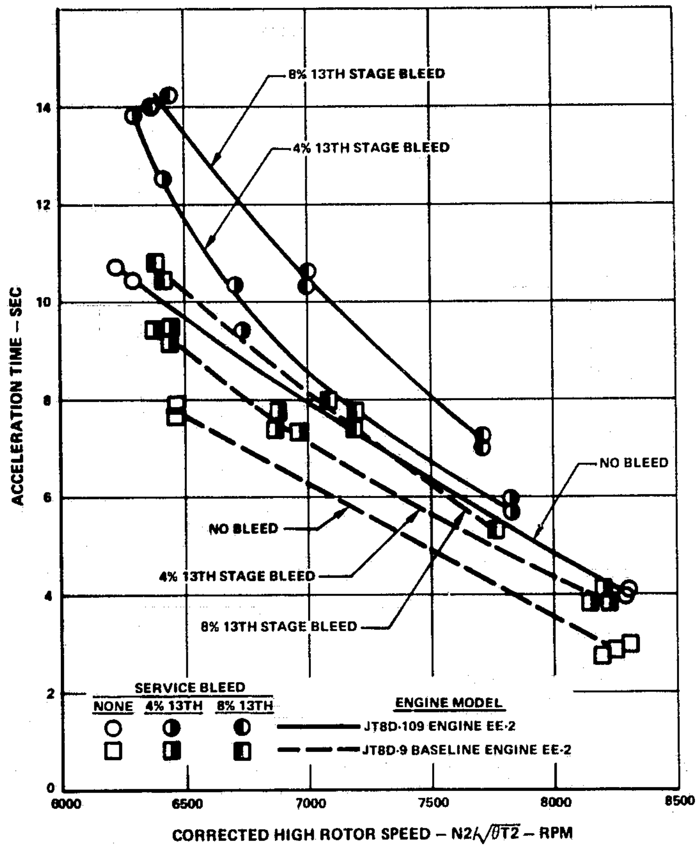


Figure 41 JT8D-109/D-9 Sea Level Static Acceleration Comparison

TABLE XXIV

JT8D-9/D-109 ACCELERATION TIMES (SECONDS)
(GROUND IDLE TO TAKEOFF – NO AIRBLEED)

Engine	JT8D-9	JT8D-109	Δ
EE-1	7.6	9.3	+1.7
EE-2	7.6	10.9	+3.3
EE-3	6.6	10.4	+3.8
Average	7.3	10.2	+2.9 sec

Dynamic simulation analytical studies predicted that the JT8D-109 engine would require the incorporation of a flight idle-minimum idle control system. The flight idle is required to provide acceptable aborted landing go-around acceleration capability. Analysis of DC-9 flight test results and EE-3 NASA test data indicated that a minimum JT8D-109 flight idle setting of 7.5 percent of takeoff thrust ($N2/\sqrt{\theta T2}$ = 7750 rpm) is required to achieve the acceleration requirement at an approach condition of 10,000 ft., 0.2 Mn (see Figure 42). Previous estimates based on dynamic simulation analysis predicted the flight idle setting to be at 6 percent of takeoff thrust ($N2/\sqrt{\theta T2}$ = 7600 rpm) at this approach condition. Minimum idle at this condition provides 3 percent of takeoff thrust. A comparison of dynamic simulator results, EE-3 NASA test data, and DC-9 refan flight test results is presented in Figure 42. As shown, the DC-9 flight test results indicated a flight idle setting of $N2/\sqrt{\theta T2}$ = 7500 rpm at the 8600 ft., 128 knot DC-9 approach condition utilized during the flight test program. This flight idle setting was found acceptable during DC-9 flight testing.

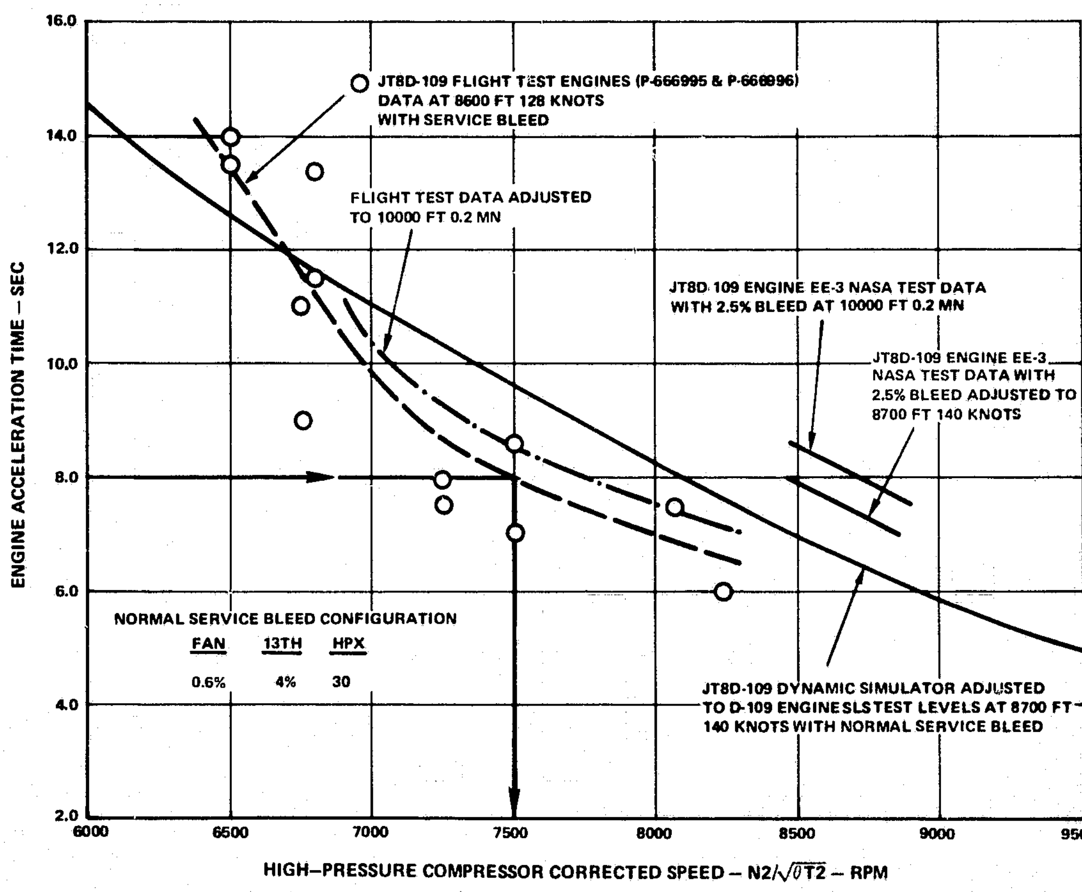


Figure 42 JT8D-109/D-9 Acceleration Comparison – DC-9 Flight Test

F. ALTITUDE TRANSIENT TESTS

Engine tests were conducted at the NASA LeRC altitude facility to determine the JT8D-109 altitude transient characteristics. Testing was conducted with an inlet distortion screen simulating the 727 center engine distortion. Three test sequences were conducted as follows:

1) Acceleration-deceleration

2) Wave-off acceleration

3) Decelerations

1. Test Procedures

a. Acceleration-Deceleration Tests

Snap accelerations were made from a stabilized idle to maximum continuous power (cold acceleration). The engine was stabilized two minutes, and a snap deceleration to idle was performed; thirty seconds after snap deceleration initiation, a snap acceleration to maximum continuous power was made (hot acceleration). This procedure was repeated for two idle power settings, ground idle (840 lb. Fn) and flight idle as determined in Section E testing. Data were acquired at the conditions shown in Figure 43.

b. Wave-off Accelerations

Snap accelerations from several part power throttle settings to maximum continuous power were performed at the following conditions:

Altitude (ft)	Mn	TT2 (°F)
10,000	0.2	27

c. Decelerations

Decelerations from maximum continuous power to idle were performed at the conditions shown in Figure 43.

2. Test Results and Discussion of Results

The JT8D-109 engine demonstrated stable operation during both hot and cold snap accelerations from both ground and flight idle power settings around the DC-9/727 flight envelope as shown in Figure 43.

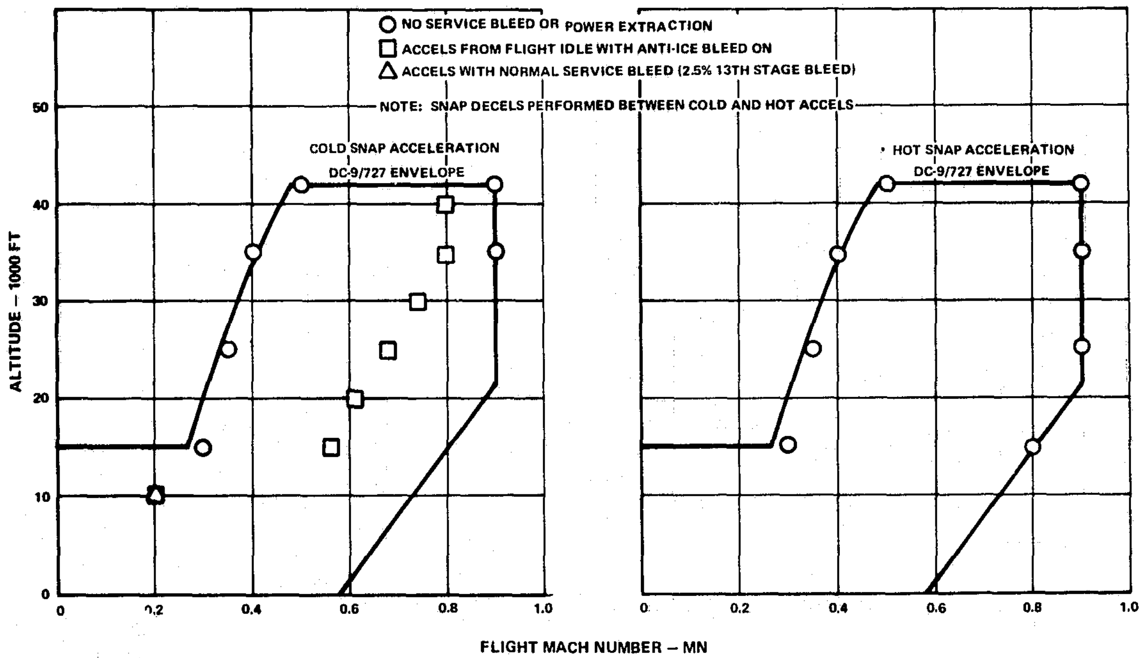


Figure 43 JT8D-109 Engine EE-3 Altitude Test Summary with 727 Center Inlet Distortion

Snap decelerations conducted during altitude tests at the NASA LeRC test facility indicated pressure fluctuations at altitudes above 15,000 ft. It is suspected that these pressure fluctuations could have been caused by low-pressure compressor surge and surge bleed valve cycling, or induced by the test facility. Further testing at NASA indicated that the presure disturbances could be eliminated by manually opening the 13th-stage surge bleeds. Snap engine accelerations were successfully performed from the apparent unstable condition.

Engine deceleration transients performed during the DC-9 refan flight test program demonstrated stable engine operation in the flight test envelope. Pressure fluctuations as experienced in the NASALeRC testing were not evident. In addition, stable engine operation was also demonstrated during sea level testing conducted at P&WA test facilities.

G. LOW-PRESSURE COMPRESSOR SURGE TESTS (Cross-Bleed Surge Check)

Tests were conducted to determine the low compressor surge margin characteristics of the JT8D-109 engine. The procedure used in this determination (known as cross-bleed surge check) involved the use of the high pressure bleed air available at the 13th-stage discharge to back-pressure the low-pressure compressor, thus raising the low-pressure compressor operating line. The equipment used consisted of tubing to connect the 13th-stage bleed ports to the sixth-stage bleed ports on each side of the engine, an electrically operated shutoff valve in each tube, and provisions for installing various size orifices to control the flow recirculating from the 13th-stage discharge to the sixth-stage discharge, thus controlling the back pressure at the low-pressure compressor discharge.

1. Test Procedure

The following is a description of the test procedure normally utilized in conducting cross-bleed surge checks:

With the shutoff valves in the cross-bleed system closed, the engine is idled for five minutes and then slowly accelerated to the appropriate stabilizing speed for the orifice diameter being used. The engine is stabilized for one minute, and N1 rpm and engine inlet total temperature are recorded. Proper valve operation is checked by opening the cross-bleed system shutoff valves to confirm that the N1 speed reduction corresponds to that required for the orifice size being tested.

Following a ten minute stabilization period, the engine is accelerated slowly over a period of approximately two minutes or more until engine surge occurs, a corrected N1 speed of 7400 rpm is reached, or the engine exhaust gas temperature limit is reached. If no surge occurs, the engine is stabilized at a corrected N1 speed of 7400 rpm, or at the exhaust gas temperature limit, whichever occurs first. At this condition, a full instrumentation reading is taken.

2. Test Results and Discussion of Results

Operation was limited by exhaust gas temperatures or N1 speeds for all conditions tested. No surges were encountered. Table XXV presents a summary of the cross-bleed results for testing conducted on refan engines EE-1 and EE-2 compared to the fan/LPC rig defined surge margin. As indicated, EE-1 and EE-2 exhibited LPC surge margin levels in excess of those previously attained by the rig with a clean inlet. The cross-bleed test data are presented in Figure 44. These results indicate there is no detrimental effect on the JT8D-109 low compressor surge margin during full scale engine testing.

TABLE XXV

JT8D-109 LOW-PRESSURE COMPRESSOR SURGE TESTS
(Cross-Bleed Surge Check)

	% Surge Margin** at $N1/\sqrt{\theta T2} \approx 6500$ rpm			
Inlet Screen	Rig (D-109) Baseline LPC	EE-1 (D-9) Baseline LPC	EE-1 (D-109)	EE-2 (D-109)
Clean Inlet	10.4	>11.8*	>12.3*	>11.9*
Sea Level Static Center	12.2	–	> 9.9*	–
35 kt. X-wind Center	9.2	–	> 9.7*	–
30 kt. X-wind Pod	9.3	–	>10.9*	–

*Extrapolation based on passing the rig-defined surge line slope (for the appropriate inlet distortion) through the engine data.

$$**\% \text{ Surge margin} = \frac{S/L - O/L}{S/L} \times 100 \text{ at constant corrected airflow.}$$

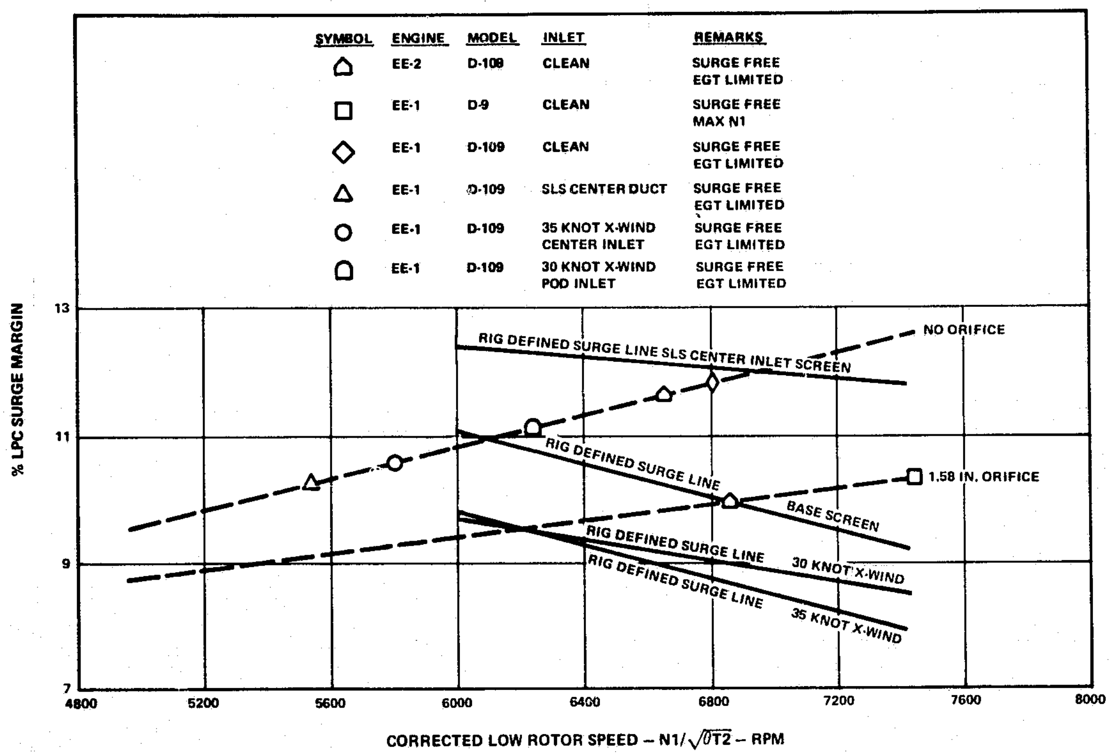


Figure 44 JT8D-109 Cross-Bleed Low-Pressure Compressor Stall Check

VI. CONCLUDING REMARKS

Phase II of the JT8D refan program has determined that the program objective of engine noise reduction, while providing acceptable engine performance and durability, has been achieved.

Sea level static performance testing of the JT8D-109 refan engine showed a thrust specific fuel consumption decrease of 12.76%, as compared to the base JT8D-9 configuration, which is within the design goal of 12.66%.

The thrust specific fuel consumption at altitude average cruise power was 0.5% higher than the design goal.

The thrust specific fuel consumption at altitude maximum cruise power was higher than design goals by 1.7 – 3.7% due primarily to higher than anticipated fan duct pressure losses and slightly lower than predicted exhaust nozzle performance.

The JT8D-100 engine stability and flight starting characteristics were satisfactory and consistent with JT8D-9 base engine experience.

Engine acceleration response characteristics analysis has indicated the need for a flight idle power setting to provide acceptable aborted landing go-around acceleration capability. This requirement verified Phase I dynamic simulation analytical predictions and is due to a 40% increase in low rotor inertia.

A performance improvement program should be conducted as part of any future program to certify a JT8D-100 engine model.

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APPENDIX A

ESTIMATED GENERAL PERFORMANCE CHARACTERISTICS

ESTIMATED GENERAL PERFORMANCE CHARACTERISTICS

This section presents the estimated performance of a production JT8D-109 engine. These data are based on the performance development test results obtained during the refan program. The delta performance benefits attributable to the refan components have been combined with the performance level of a 1971 production JT8D-9 high spool. These data used the following base assumptions.

18,400 BTU/lb. Fuel Heating Value	No Compressor Airbleed
ICAO Standard Atmosphere	No Accessory Loading
100% Inlet Pressure Recovery	
Reference Nozzles (discharge area = 8.11 sq. ft.)*	Acoustic Treatment in Fan Cases

The performance estimates do not include any external nacelle drag induced by free stream Mach No.

The following is a summary of the data presented in Appendix A:

Power Setting	Altitude	Mn	Tam
Takeoff	Sea Level	0.0	59°F
	2,000′	0.1	84°F
	4,000′	0.2	120°F
	6,000′	0.3	
	8,000′	0.4	
	10,000′		
	12,000′		
	14,000′		
Maximum Cruise	20,000′	0.65	Std.
	25,000′	0.70	Std. + 18°F
	30,000′	0.75	
	35.000′	0.80	
	40,000′	0.85	
Maximum Climb and Maximum Continuous	Sea Level	0.2	Std.
	5,000′	0.4	Std. + 18°F
	10,000′	0.6	
	15,000′	0.8	
	20,000′		
	25,000′		
	30,000′		
	35,000′		
	40,000′		
Altitude Power Range	Sea Level	0.0	Std
	5,000′	0.2	
	10,000′	0.4	
	15,000′	0.6	
		0.8	
	20,000′	0.65	Std.
	25,000′	0.70	
	30,000′	0.75	
	35,000′	0.80	
	40,000′	0.85	

***JT8D-109 performance testing was conducted with a reference mixed exhaust jet with an area of 8.33 sq. ft. This area was reduced to 8.11 sq. ft. for these performance estimates in order to maintain measured rotor speed and airflow levels at takeoff thrust with component performance adjusted to eliminate JT8D-9 baseline differences.**

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
TAKEOFF RATING
TAMB = 59 DEG F

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.00	16600	0.4971	8251	16600	7303	7303	11329	11329	464.	2.12
2000	0.00	15895	0.5034	8000	17093	7417	7417	11407	11407	469	2.10
4000	0.00	14770	0.5033	7433	17097	7416	7416	11408	11408	469	2.10
6000	0.00	13697	0.5035	6896	17086	7415	7415	11407	11407	469	2.10
8000	0.00	12702	0.5034	6393	17092	7416	7416	11408	11408	469	2.10
10000	0.00	11762	0.5033	5920	17093	7415	7415	11407	11407	469	2.10
12000	0.00	10879	0.5033	5475	17093	7416	7416	11407	11407	469	2.10
14000	0.00	10016	0.5038	5046	17034	7409	7409	11406	11406	468	2.10
0	0.10	15141	0.5466	8276	15141	7301	7294	11332	11321	464	2.12
2000	0.10	14538	0.5524	8031	15634	7421	7414	11413	11402	470	2.10
4000	0.10	13506	0.5524	7460	15634	7421	7413	11413	11401	470	2.10
6000	0.10	12531	0.5524	6922	15632	7421	7413	11415	11403	470	2.10
8000	0.10	11618	0.5523	6417	15634	7421	7413	11413	11401	470	2.10
10000	0.10	10761	0.5523	5943	15638	7420	7413	11413	11402	469	2.10
12000	0.10	9953	0.5523	5497	15639	7420	7413	11413	11402	469	2.10
14000	0.10	9169	0.5528	5068	15593	7414	7406	11410	11399	469	2.11
0	0.20	13986	0.5980	8364	13986	7310	7281	11349	11304	464	2.14
2000	0.20	13478	0.6027	8123	14494	7427	7397	11428	11383	470	2.12
4000	0.20	12519	0.6027	7545	14492	7427	7398	11429	11384	470	2.12
6000	0.20	11619	0.6027	7002	14493	7427	7398	11429	11383	470	2.12
8000	0.20	10775	0.6026	6492	14499	7428	7398	11428	11383	470	2.12
10000	0.20	9974	0.6026	6011	14495	7427	7397	11429	11384	470	2.12
12000	0.20	9227	0.6025	5560	14497	7427	7398	11428	11383	470	2.12
14000	0.20	8509	0.6030	5130	14471	7424	7395	11428	11383	469	2.12
0	0.30	13062	0.6514	8507	13062	7310	7245	11358	11257	463	2.16
2000	0.30	12692	0.6533	8291	13648	7437	7371	11450	11349	470	2.13
4000	0.30	11792	0.6533	7703	13650	7438	7372	11451	11349	470	2.13
6000	0.30	10943	0.6532	7148	13650	7438	7371	11451	11349	470	2.13
8000	0.30	10143	0.6532	6626	13649	7437	7371	11451	11349	470	2.13
10000	0.30	9393	0.6532	6135	13650	7438	7372	11450	11348	470	2.13
12000	0.30	8686	0.6533	5674	13647	7437	7371	11450	11349	470	2.13
14000	0.30	8023	0.6533	5241	13645	7437	7371	11450	11348	470	2.13
0	0.40	12336	0.7050	8696	12336	7294	7180	11359	11181	461	2.19
2000	0.40	12066	0.7040	8495	12976	7425	7309	11449	11270	468	2.15
4000	0.40	11203	0.7042	7889	12969	7423	7307	11442	11263	468	2.15
6000	0.40	10400	0.7041	7323	12973	7426	7310	11443	11264	468	2.15
8000	0.40	9640	0.7041	6788	12973	7425	7309	11443	11264	468	2.15
10000	0.40	8927	0.7042	6286	12972	7425	7309	11442	11264	468	2.15
12000	0.40	8258	0.7040	5814	12975	7426	7309	11444	11266	468	2.15
14000	0.40	7629	0.7042	5372	12974	7425	7309	11443	11264	468	2.15

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE   100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
TAKEOFF RATING
TAMB = 59 DEG F

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.00	3.93	1.54	6.60	1.78	15.48	2.37	1.65	1.19	1.76	2.73	1.61
2000	0.00	4.02	1.56	6.76	1.80	15.88	2.40	1.67	1.20	1.79	2.77	1.63
4000	0.00	4.02	1.56	6.76	1.80	15.88	2.40	1.67	1.20	1.80	2.77	1.63
6000	0.00	4.02	1.56	6.76	1.80	15.87	2.40	1.67	1.20	1.79	2.77	1.63
8000	0.00	4.02	1.56	6.76	1.80	15.88	2.40	1.67	1.20	1.79	2.77	1.63
10000	0.00	4.02	1.56	6.76	1.80	15.87	2.40	1.67	1.20	1.79	2.77	1.63
12000	0.00	4.02	1.56	6.76	1.80	15.88	2.40	1.67	1.20	1.79	2.77	1.63
14000	0.00	4.01	1.56	6.74	1.80	15.83	2.40	1.67	1.20	1.79	2.77	1.63
0	0.10	3.92	1.54	6.57	1.78	15.43	2.37	1.65	1.19	1.76	2.73	1.60
2000	0.10	4.02	1.56	6.75	1.80	15.84	2.40	1.67	1.20	1.79	2.77	1.62
4000	0.10	4.01	1.56	6.75	1.80	15.84	2.40	1.67	1.20	1.79	2.77	1.62
6000	0.10	4.01	1.56	6.75	1.80	15.84	2.40	1.67	1.20	1.79	2.77	1.62
8000	0.10	4.02	1.56	6.75	1.80	15.84	2.40	1.67	1.20	1.79	2.77	1.62
10000	0.10	4.02	1.56	6.75	1.80	15.84	2.40	1.67	1.20	1.79	2.77	1.62
12000	0.10	4.02	1.56	6.75	1.80	15.85	2.40	1.67	1.20	1.79	2.77	1.62
14000	0.10	4.01	1.56	6.73	1.80	15.80	2.40	1.66	1.19	1.79	2.77	1.62
0	0.20	3.90	1.54	6.53	1.78	15.31	2.36	1.64	1.19	1.74	2.71	1.59
2000	0.20	4.00	1.56	6.71	1.80	15.74	2.39	1.66	1.19	1.78	2.75	1.61
4000	0.20	4.00	1.56	6.71	1.80	15.75	2.39	1.66	1.19	1.77	2.75	1.61
6000	0.20	4.00	1.56	6.71	1.80	15.75	2.39	1.66	1.19	1.78	2.75	1.61
8000	0.20	4.00	1.56	6.71	1.80	15.75	2.39	1.66	1.19	1.78	2.75	1.61
10000	0.20	4.00	1.56	6.71	1.80	15.75	2.39	1.66	1.19	1.78	2.75	1.61
12000	0.20	4.00	1.56	6.71	1.80	15.75	2.39	1.66	1.19	1.78	2.75	1.61
14000	0.20	3.99	1.56	6.70	1.80	15.73	2.39	1.66	1.19	1.77	2.75	1.61
0	0.30	3.87	1.53	6.45	1.77	15.11	2.34	1.62	1.18	1.71	2.68	1.57
2000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.76	2.72	1.60
4000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.76	2.72	1.60
6000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.76	2.72	1.60
8000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.76	2.72	1.60
10000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.76	2.72	1.60
12000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.75	2.72	1.60
14000	0.30	3.98	1.55	6.65	1.79	15.59	2.37	1.64	1.19	1.76	2.72	1.60
0	0.40	3.82	1.52	6.35	1.76	14.80	2.32	1.60	1.18	1.68	2.65	1.54
2000	0.40	3.94	1.54	6.56	1.78	15.31	2.35	1.63	1.18	1.72	2.69	1.57
4000	0.40	3.94	1.54	6.56	1.78	15.30	2.35	1.62	1.18	1.72	2.69	1.57
6000	0.40	3.94	1.54	6.56	1.78	15.31	2.35	1.63	1.18	1.72	2.69	1.57
8000	0.40	3.94	1.54	6.56	1.78	15.30	2.35	1.62	1.18	1.72	2.69	1.57
10000	0.40	3.94	1.54	6.56	1.78	15.31	2.35	1.62	1.18	1.72	2.69	1.57
12000	0.40	3.94	1.54	6.56	1.78	15.31	2.35	1.63	1.18	1.72	2.69	1.57
14000	0.40	3.94	1.54	6.56	1.78	15.31	2.35	1.62	1.18	1.72	2.69	1.57

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
TAKEOFF RATING
TAMB = 84 DEG F

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.00	16609	0.5122	8507	16609	7473	7300	11586	11317	464	2.12
2000	0.00	15447	0.5121	7911	16611	7473	7299	11586	11316	464	2.12
4000	0.00	14341	0.5123	7347	16602	7473	7299	11586	11317	464	2.12
6000	0.00	13316	0.5122	6820	16611	7473	7299	11586	11317	464	2.12
8000	0.00	12342	0.5122	6322	16608	7473	7299	11586	11317	464	2.12
10000	0.00	11428	0.5123	5854	16607	7474	7300	11588	11318	464	2.12
12000	0.00	10539	0.5126	5402	16559	7465	7292	11584	11315	463	2.12
14000	0.00	9650	0.5137	4957	16412	7442	7268	11578	11309	461	2.13
0	0.10	15167	0.5630	8539	15167	7478	7297	11593	11312	464	2.12
2000	0.10	14100	0.5630	7938	15163	7476	7295	11592	11311	464	2.12
4000	0.10	13095	0.5630	7372	15159	7473	7292	11592	11311	464	2.12
6000	0.10	12153	0.5631	6843	15160	7476	7294	11592	11311	464	2.12
8000	0.10	11266	0.5630	6343	15161	7475	7294	11591	11310	464	2.12
10000	0.10	10431	0.5631	5873	15159	7476	7295	11591	11311	464	2.12
12000	0.10	9624	0.5634	5422	15122	7468	7287	11590	11309	463	2.12
14000	0.10	8812	0.5649	4978	14986	7446	7266	11584	11304	461	2.13
0	0.20	13998	0.6159	8622	13998	7480	7277	11606	11291	464	2.14
2000	0.20	13021	0.6158	8019	14003	7481	7278	11605	11290	464	2.14
4000	0.20	12097	0.6158	7449	14004	7482	7279	11607	11292	464	2.14
6000	0.20	11227	0.6159	6914	14005	7484	7281	11607	11292	464	2.14
8000	0.20	10405	0.6158	6407	14001	7481	7278	11606	11291	464	2.14
10000	0.20	9635	0.6158	5933	14001	7481	7278	11605	11290	464	2.14
12000	0.20	8904	0.6160	5485	13991	7479	7276	11605	11290	464	2.14
14000	0.20	8162	0.6176	5041	13882	7459	7256	11600	11285	462	2.15
0	0.30	13048	0.6711	8756	13048	7470	7232	11599	11229	463	2.16
2000	0.30	12134	0.6711	8144	13049	7471	7233	11599	11229	463	2.16
4000	0.30	11274	0.6711	7566	13051	7471	7233	11601	11231	463	2.16
6000	0.30	10458	0.6711	7019	13046	7469	7231	11598	11227	462	2.16
8000	0.30	9697	0.6712	6508	13049	7471	7233	11600	11229	463	2.16
10000	0.30	8979	0.6712	6027	13049	7473	7234	11601	11231	463	2.16
12000	0.30	8302	0.6712	5572	13043	7470	7231	11598	11227	463	2.16
14000	0.30	7632	0.6727	5133	12979	7463	7224	11603	11233	462	2.17
0	0.40	12333	0.7261	8955	12333	7456	7169	11601	11154	461	2.19
2000	0.40	11469	0.7260	8326	12333	7455	7168	11600	11153	461	2.19
4000	0.40	10654	0.7260	7734	12333	7453	7166	11599	11152	461	2.19
6000	0.40	9886	0.7261	7178	12332	7455	7168	11601	11154	461	2.19
8000	0.40	9166	0.7260	6654	12334	7455	7168	11601	11154	461	2.19
10000	0.40	8486	0.7261	6162	12332	7455	7168	11602	11155	461	2.19
12000	0.40	7849	0.7261	5699	12332	7455	7168	11601	11154	461	2.19
14000	0.40	7234	0.7268	5258	12304	7451	7164	11604	11157	460	2.19

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
TAKEOFF RATING
TAMB = 84 DEG F

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.00	3.93	1.54	6.58	1.78	15.46	2.36	1.65	1.19	1.76	2.73	1.61
2000	0.00	3.93	1.54	6.58	1.78	15.46	2.36	1.65	1.19	1.76	2.73	1.61
4000	0.00	3.93	1.54	6.58	1.78	15.46	2.36	1.65	1.19	1.76	2.73	1.61
6000	0.00	3.93	1.54	6.58	1.78	15.46	2.36	1.65	1.19	1.76	2.73	1.61
8000	0.00	3.93	1.54	6.58	1.78	15.46	2.36	1.65	1.19	1.76	2.73	1.61
10000	0.00	3.93	1.54	6.59	1.78	15.46	2.36	1.65	1.19	1.76	2.73	1.61
12000	0.00	3.92	1.54	6.57	1.78	15.42	2.36	1.65	1.19	1.76	2.73	1.61
14000	0.00	3.89	1.54	6.51	1.78	15.30	2.36	1.65	1.19	1.75	2.73	1.60
0	0.10	3.93	1.54	6.57	1.78	15.43	2.36	1.65	1.19	1.76	2.73	1.61
2000	0.10	3.92	1.54	6.57	1.78	15.42	2.36	1.65	1.19	1.76	2.73	1.61
4000	0.10	3.92	1.54	6.57	1.78	15.42	2.36	1.65	1.19	1.76	2.73	1.61
6000	0.10	3.92	1.54	6.57	1.78	15.42	2.36	1.65	1.19	1.76	2.73	1.61
8000	0.10	3.92	1.54	6.57	1.78	15.42	2.36	1.65	1.19	1.76	2.73	1.61
10000	0.10	3.92	1.54	6.57	1.78	15.42	2.36	1.65	1.19	1.76	2.73	1.60
12000	0.10	3.91	1.54	6.55	1.78	15.39	2.36	1.65	1.19	1.76	2.73	1.60
14000	0.10	3.88	1.54	6.50	1.77	15.27	2.35	1.64	1.19	1.75	2.73	1.60
0	0.20	3.90	1.54	6.52	1.77	15.30	2.35	1.64	1.19	1.74	2.71	1.59
2000	0.20	3.90	1.54	6.52	1.77	15.30	2.35	1.64	1.19	1.74	2.71	1.59
4000	0.20	3.90	1.54	6.52	1.77	15.30	2.35	1.64	1.19	1.74	2.71	1.59
6000	0.20	3.91	1.54	6.52	1.77	15.31	2.35	1.64	1.19	1.74	2.71	1.59
8000	0.20	3.90	1.54	6.52	1.77	15.30	2.35	1.64	1.19	1.74	2.71	1.59
10000	0.20	3.90	1.54	6.52	1.77	15.30	2.35	1.64	1.19	1.74	2.71	1.59
12000	0.20	3.90	1.54	6.51	1.77	15.29	2.35	1.64	1.19	1.74	2.71	1.59
14000	0.20	3.87	1.54	6.47	1.77	15.19	2.35	1.64	1.19	1.73	2.71	1.59
0	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
2000	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
4000	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
6000	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
8000	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
10000	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
12000	0.30	3.87	1.53	6.44	1.76	15.06	2.33	1.62	1.18	1.71	2.69	1.57
14000	0.30	3.85	1.53	6.42	1.76	15.01	2.33	1.62	1.18	1.71	2.69	1.57
0	0.40	3.82	1.52	6.34	1.75	14.76	2.31	1.60	1.18	1.68	2.65	1.54
2000	0.40	3.82	1.52	6.34	1.75	14.76	2.31	1.60	1.18	1.68	2.65	1.54
4000	0.40	3.82	1.52	6.34	1.75	14.75	2.31	1.60	1.18	1.68	2.65	1.54
6000	0.40	3.82	1.52	6.34	1.75	14.76	2.31	1.60	1.18	1.68	2.65	1.54
8000	0.40	3.82	1.52	6.34	1.75	14.76	2.31	1.60	1.18	1.68	2.65	1.54
10000	0.40	3.82	1.52	6.34	1.75	14.76	2.31	1.60	1.18	1.68	2.65	1.54
12000	0.40	3.82	1.52	6.34	1.75	14.76	2.31	1.60	1.18	1.68	2.65	1.54
14000	0.40	3.81	1.52	6.33	1.75	14.73	2.31	1.60	1.18	1.68	2.65	1.54

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
TAKEOFF RATING
TAMB = 120 DEG F

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.00	14009	0.5140	7201	14009	7179	6791	11647	11017	432	2.25
2000	0.00	13025	0.5140	6694	14007	7177	6789	11645	11015	432	2.25
4000	0.00	12074	0.5145	6211	13977	7173	6785	11644	11014	432	2.25
6000	0.00	11230	0.5139	5771	14008	7178	6789	11644	11015	432	2.25
8000	0.00	10408	0.5140	5350	14006	7178	6789	11644	11015	432	2.25
10000	0.00	9619	0.5143	4947	13979	7175	6787	11645	11016	431	2.25
12000	0.00	8849	0.5152	4559	13964	7164	6777	11643	11013	430	2.25
14000	0.00	8133	0.5161	4197	13632	7156	6769	11643	11013	429	2.25
0	0.10	12666	0.5706	7227	12666	7182	6787	11651	11010	432	2.25
2000	0.10	11781	0.5706	6723	12669	7183	6788	11652	11011	432	2.25
4000	0.10	10942	0.5705	6243	12667	7182	6787	11649	11008	432	2.25
6000	0.10	10156	0.5706	5795	12669	7183	6788	11646	11005	432	2.25
8000	0.10	9413	0.5706	5371	12667	7183	6787	11650	11009	432	2.25
10000	0.10	8700	0.5711	4968	12642	7180	6785	11651	11010	432	2.25
12000	0.10	8001	0.5722	4578	12571	7170	6775	11649	11008	430	2.26
14000	0.10	7354	0.5733	4215	12507	7162	6768	11649	11008	429	2.26
0	0.20	11576	0.6307	7301	11576	7190	6774	11649	10975	433	2.27
2000	0.20	10765	0.6306	6788	11576	7190	6774	11649	10975	433	2.27
4000	0.20	9999	0.6307	6306	11575	7191	6775	11650	10976	433	2.27
6000	0.20	9281	0.6306	5852	11577	7191	6775	11657	10983	433	2.27
8000	0.20	8609	0.6304	5427	11585	7191	6775	11653	10979	433	2.27
10000	0.20	7963	0.6308	5023	11572	7190	6774	11654	10980	433	2.27
12000	0.20	7320	0.6323	4629	11502	7181	6765	11649	10975	431	2.27
14000	0.20	6727	0.6336	4262	11441	7174	6759	11653	10979	430	2.28
0	0.30	10672	0.6939	7406	10672	7194	6744	11651	10923	433	2.30
2000	0.30	9923	0.6939	6885	10671	7193	6744	11651	10923	433	2.30
4000	0.30	9215	0.6941	6396	10667	7193	6744	11649	10921	433	2.30
6000	0.30	8557	0.6939	5938	10674	7194	6745	11648	10920	433	2.30
8000	0.30	7926	0.6942	5502	10666	7193	6743	11649	10921	433	2.30
10000	0.30	7346	0.6938	5098	10678	7196	6746	11654	10926	433	2.30
12000	0.30	6761	0.6953	4701	10623	7188	6739	11653	10925	432	2.30
14000	0.30	6209	0.6976	4331	10560	7184	6735	11659	10931	431	2.31
0	0.40	9949	0.7596	7557	9949	7200	6704	11642	10841	432	2.34
2000	0.40	9251	0.7596	7027	9949	7199	6703	11642	10841	432	2.34
4000	0.40	8596	0.7596	6529	9951	7199	6703	11642	10840	432	2.34
6000	0.40	7977	0.7596	6059	9951	7199	6703	11642	10840	432	2.34
8000	0.40	7395	0.7595	5617	9951	7200	6704	11642	10840	432	2.34
10000	0.40	6847	0.7595	5200	9950	7199	6703	11644	10842	432	2.34
12000	0.40	6318	0.7604	4804	9926	7196	6701	11641	10840	431	2.34
14000	0.40	5803	0.7626	4425	9869	7192	6697	11644	10842	430	2.34

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
TAKEOFF RATING
TAMB = 120 DEG F

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.00	3.42	1.46	5.69	1.69	13.35	2.23	1.56	1.16	1.61	2.58	1.50
2000	0.00	3.42	1.46	5.68	1.69	13.35	2.23	1.56	1.16	1.61	2.58	1.50
4000	0.00	3.42	1.46	5.68	1.68	13.33	2.22	1.56	1.16	1.61	2.58	1.50
6000	0.00	3.42	1.46	5.68	1.69	13.35	2.23	1.56	1.16	1.61	2.58	1.50
8000	0.00	3.42	1.46	5.68	1.69	13.35	2.23	1.56	1.16	1.61	2.58	1.50
10000	0.00	3.42	1.46	5.68	1.69	13.33	2.23	1.56	1.16	1.61	2.58	1.50
12000	0.00	3.40	1.46	5.65	1.68	13.27	2.22	1.55	1.16	1.61	2.59	1.50
14000	0.00	3.39	1.46	5.63	1.68	13.23	2.22	1.55	1.16	1.60	2.59	1.50
0	0.10	3.42	1.46	5.68	1.68	13.32	2.22	1.56	1.16	1.61	2.58	1.50
2000	0.10	3.42	1.46	5.68	1.68	13.33	2.22	1.56	1.16	1.61	2.58	1.50
4000	0.10	3.42	1.46	5.67	1.68	13.32	2.22	1.56	1.16	1.61	2.58	1.50
6000	0.10	3.42	1.46	5.68	1.68	13.32	2.22	1.56	1.16	1.61	2.58	1.50
8000	0.10	3.42	1.46	5.68	1.68	13.32	2.22	1.56	1.16	1.61	2.58	1.50
10000	0.10	3.42	1.46	5.67	1.68	13.31	2.22	1.56	1.16	1.60	2.58	1.50
12000	0.10	3.40	1.46	5.64	1.68	13.25	2.22	1.55	1.16	1.60	2.58	1.50
14000	0.10	3.39	1.46	5.63	1.68	13.21	2.22	1.55	1.16	1.60	2.58	1.49
0	0.20	3.41	1.46	5.65	1.68	13.22	2.22	1.55	1.16	1.59	2.56	1.49
2000	0.20	3.41	1.46	5.65	1.68	13.22	2.22	1.55	1.16	1.59	2.56	1.49
4000	0.20	3.41	1.46	5.65	1.68	13.22	2.22	1.55	1.16	1.59	2.56	1.49
6000	0.20	3.41	1.46	5.65	1.68	13.23	2.22	1.55	1.16	1.59	2.56	1.49
8000	0.20	3.41	1.46	5.65	1.68	13.23	2.22	1.55	1.16	1.59	2.56	1.49
10000	0.20	3.41	1.46	5.65	1.68	13.22	2.22	1.55	1.16	1.59	2.56	1.49
12000	0.20	3.40	1.46	5.62	1.68	13.17	2.22	1.54	1.16	1.59	2.56	1.48
14000	0.20	3.39	1.46	5.60	1.68	13.12	2.22	1.54	1.16	1.58	2.56	1.48
0	0.30	3.39	1.46	5.59	1.68	13.03	2.21	1.53	1.16	1.57	2.54	1.47
2000	0.30	3.39	1.46	5.59	1.68	13.03	2.20	1.53	1.16	1.57	2.54	1.47
4000	0.30	3.39	1.46	5.59	1.68	13.03	2.20	1.53	1.16	1.57	2.54	1.47
6000	0.30	3.39	1.46	5.60	1.68	13.03	2.21	1.53	1.16	1.57	2.54	1.47
8000	0.30	3.39	1.46	5.59	1.68	13.02	2.20	1.53	1.16	1.57	2.54	1.47
10000	0.30	3.39	1.46	5.60	1.68	13.04	2.21	1.53	1.16	1.57	2.54	1.47
12000	0.30	3.38	1.46	5.58	1.68	13.00	2.20	1.53	1.16	1.56	2.54	1.46
14000	0.30	3.37	1.46	5.56	1.68	12.96	2.21	1.52	1.16	1.56	2.54	1.46
0	0.40	3.36	1.45	5.52	1.67	12.78	2.19	1.51	1.15	1.53	2.50	1.44
2000	0.40	3.36	1.45	5.52	1.67	12.77	2.19	1.51	1.15	1.53	2.50	1.44
4000	0.40	3.36	1.45	5.52	1.67	12.77	2.19	1.51	1.15	1.53	2.50	1.44
6000	0.40	3.36	1.45	5.52	1.67	12.77	2.19	1.51	1.15	1.53	2.50	1.44
8000	0.40	3.36	1.45	5.52	1.67	12.77	2.19	1.51	1.15	1.53	2.50	1.44
10000	0.40	3.36	1.45	5.52	1.67	12.77	2.19	1.51	1.15	1.53	2.50	1.44
12000	0.40	3.36	1.45	5.51	1.67	12.75	2.19	1.51	1.15	1.53	2.50	1.44
14000	0.40	3.35	1.45	5.49	1.67	12.72	2.19	1.50	1.15	1.53	2.50	1.44

PRATT AND WHITNEY AIRCRAFT
J18D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB
MAXIMUM CONTINUOUS RATING

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.20	12193	0.5903	7198	12193	6932	6904	11128	11084	442	2.24
0	0.40	10522	0.7071	7440	10522	6938	6830	11124	10950	441	2.30
0	0.60	9363	0.8259	7733	9363	6913	6677	11114	10734	433	2.39
0	0.80	8507	0.9493	8075	8507	6850	6450	11138	10487	419	2.50
5000	0.20	12501	0.5964	7455	15021	7426	7527	11337	11491	475	2.10
5000	0.40	11198	0.6914	7742	13455	7404	7417	11358	11378	472	2.14
5000	0.60	10432	0.7849	8187	12534	7318	7193	11324	11130	464	2.21
5000	0.80	9999	0.8816	8815	12014	7237	6934	11367	10892	450	2.30
10000	0.20	10954	0.5954	6522	15918	7485	7725	11337	11702	483	2.08
10000	0.40	9956	0.6855	6825	14469	7509	7659	11346	11573	481	2.10
10000	0.60	9491	0.7675	7285	13793	7450	7456	11376	11386	475	2.15
10000	0.80	9263	0.8549	7919	13461	7318	7140	11345	11069	462	2.23
15000	0.20	9514	0.5952	5662	16842	7495	7883	11338	11925	489	2.06
15000	0.40	8695	0.6820	5930	15392	7520	7817	11343	11791	487	2.08
15000	0.60	8416	0.7589	6386	14898	7527	7677	11349	11574	483	2.11
15000	0.80	8358	0.8352	6980	14795	7421	7378	11340	11274	472	2.17
20000	0.20	8004	0.5915	4734	17393	7530	8075	11261	12077	492	2.06
20000	0.40	7485	0.6769	5067	16266	7577	8032	11307	11985	492	2.08
20000	0.60	7328	0.7532	5519	15924	7536	7838	11345	11799	488	2.09
20000	0.80	7393	0.8271	6115	16066	7530	7634	11359	11516	481	2.12
25000	0.20	6722	0.5939	3992	18081	7639	8361	11224	12285	496	2.06
25000	0.40	6268	0.6722	4213	16861	7607	8228	11237	12155	495	2.07
25000	0.60	6244	0.7472	4665	16795	7597	8063	11300	11994	492	2.08
25000	0.80	6376	0.8216	5239	17151	7538	7800	11341	11734	487	2.09
30000	0.40	5202	0.6698	3484	17478	7629	8430	11204	12379	496	2.09
30000	0.60	5208	0.7407	3858	17497	7636	8278	11233	12177	495	2.08
30000	0.80	5424	0.8143	4416	18220	7583	8014	11316	11960	491	2.09
35000	0.40	4268	0.6705	2862	18086	7600	8585	11257	12717	497	2.13
35000	0.60	4303	0.7365	3169	18234	7631	8458	11242	12460	496	2.12
35000	0.80	4472	0.8045	3597	18947	7597	8209	11242	12147	493	2.10
40000	0.40	3321	0.6749	2241	17944	7520	8537	11345	12879	494	2.19
40000	0.60	3319	0.7382	2450	17932	7522	8378	11276	12560	493	2.19
40000	0.80	3441	0.8052	2771	18596	7482	8124	11254	12220	489	2.17

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB
MAXIMUM CONTINUOUS RATING

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.20	3.54	1.48	5.68	1.71	13.79	2.26	1.57	1.17	1.63	2.60	1.51
0	0.40	3.48	1.47	5.74	1.69	13.31	2.23	1.53	1.16	1.57	2.54	1.46
0	0.60	3.35	1.45	5.45	1.66	12.50	2.18	1.47	1.14	1.47	2.43	1.39
0	0.80	3.15	1.43	5.03	1.62	11.36	2.11	1.38	1.13	1.36	2.30	1.30
5000	0.20	4.08	1.57	6.88	1.82	16.18	2.43	1.68	1.20	1.81	2.80	1.64
5000	0.40	4.00	1.56	6.69	1.80	15.69	2.39	1.64	1.19	1.76	2.73	1.60
5000	0.60	3.85	1.53	6.37	1.76	14.75	2.32	1.59	1.17	1.66	2.63	1.53
5000	0.80	3.61	1.49	5.91	1.71	13.60	2.24	1.52	1.16	1.55	2.52	1.45
10000	0.20	4.17	1.61	7.10	1.86	16.87	2.49	1.71	1.21	1.87	2.90	1.68
10000	0.40	4.15	1.59	7.01	1.85	16.50	2.46	1.68	1.20	1.82	2.83	1.64
10000	0.60	4.02	1.56	6.70	1.81	15.70	2.39	1.63	1.19	1.74	2.72	1.58
10000	0.80	3.81	1.52	6.28	1.75	14.52	2.30	1.57	1.17	1.63	2.60	1.50
15000	0.20	4.21	1.63	7.26	1.90	17.49	2.56	1.75	1.22	1.93	3.02	1.72
15000	0.40	4.21	1.62	7.18	1.89	17.12	2.53	1.71	1.21	1.88	2.94	1.68
15000	0.60	4.16	1.60	7.02	1.85	16.50	2.46	1.67	1.20	1.81	2.82	1.63
15000	0.80	4.00	1.56	6.64	1.79	15.41	2.37	1.61	1.18	1.71	2.69	1.56
20000	0.20	4.20	1.64	7.32	1.92	17.84	2.60	1.77	1.23	1.96	3.10	1.74
20000	0.40	4.23	1.64	7.31	1.92	17.65	2.58	1.75	1.23	1.93	3.05	1.72
20000	0.60	4.22	1.63	7.20	1.89	17.14	2.53	1.71	1.21	1.87	2.95	1.67
20000	0.80	4.14	1.59	6.96	1.84	16.31	2.45	1.66	1.20	1.79	2.79	1.61
25000	0.20	4.21	1.67	7.42	1.95	18.33	2.66	1.79	1.25	2.00	3.21	1.77
25000	0.40	4.21	1.66	7.35	1.94	17.99	2.63	1.77	1.24	1.96	3.14	1.74
25000	0.60	4.22	1.65	7.29	1.92	17.62	2.59	1.74	1.23	1.92	3.06	1.71
25000	0.80	4.22	1.62	7.16	1.88	16.97	2.52	1.69	1.21	1.85	2.91	1.66
30000	0.40	4.16	1.67	7.37	1.96	18.32	2.68	1.80	1.25	2.00	3.26	1.77
30000	0.60	4.20	1.66	7.35	1.94	17.99	2.64	1.77	1.24	1.96	3.16	1.74
30000	0.80	4.22	1.65	7.26	1.92	17.48	2.58	1.73	1.22	1.91	3.04	1.70
35000	0.40	4.03	1.68	7.30	1.99	18.50	2.75	1.82	1.27	2.02	3.42	1.79
35000	0.60	4.08	1.67	7.28	1.97	18.21	2.70	1.80	1.26	1.99	3.30	1.76
35000	0.80	4.16	1.66	7.26	1.94	17.75	2.63	1.75	1.24	1.93	3.14	1.72
40000	0.40	3.87	1.68	7.10	1.99	18.17	2.76	1.82	1.27	2.01	3.48	1.79
40000	0.60	3.90	1.66	7.03	1.96	17.75	2.70	1.79	1.25	1.96	3.35	1.75
40000	0.80	3.98	1.65	7.01	1.93	17.29	2.63	1.75	1.23	1.91	3.18	1.70

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY + 18F TAMB
MAXIMUM CONTINUOUS RATING

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.20	10898	0.5964	6522	10898	6787	6646	11160	10927	424	2.31
0	0.40	9281	0.7270	6747	9281	6804	6585	11144	10784	424	2.38
0	0.60	8139	0.8666	7054	8139	6830	6485	11136	10574	420	2.46
0	0.80	7226	1.0155	7338	7226	6760	6257	11160	10330	406	2.56
5000	0.20	11617	0.5979	6945	13958	7304	7274	11347	11300	464	2.14
5000	0.40	10236	0.7049	7215	12298	7286	7171	11354	11175	461	2.19
5000	0.60	9315	0.8094	7539	11192	7217	6969	11349	10959	452	2.28
5000	0.80	8700	0.9138	7950	10454	7136	6718	11373	10767	437	2.39
10000	0.20	10330	0.5964	6160	15011	7425	7525	11337	11490	475	2.10
10000	0.40	9247	0.6914	6394	13438	7399	7411	11359	11377	472	2.14
10000	0.60	8616	0.7850	6765	12524	7318	7192	11326	11130	464	2.21
10000	0.80	8250	0.8817	7274	11989	7234	6931	11364	10886	450	2.30
15000	0.20	8988	0.5954	5351	15911	7484	7723	11337	11699	483	2.08
15000	0.40	8169	0.6855	5600	14461	7509	7658	11346	11572	481	2.10
15000	0.60	7782	0.7678	5975	13777	7449	7454	11374	11382	475	2.15
15000	0.80	7601	0.8549	6498	13456	7317	7138	11345	11067	462	2.23
20000	0.20	7614	0.5955	4534	16545	7469	7854	11312	11895	486	2.07
20000	0.40	7008	0.6830	4786	15229	7507	7802	11330	11775	485	2.09
20000	0.60	6849	0.7590	5199	14884	7527	7675	11348	11571	482	2.11
20000	0.80	6803	0.8354	5683	14783	7418	7374	11334	11267	472	2.17
25000	0.20	6371	0.5943	3786	17137	7494	8035	11264	12078	489	2.07
25000	0.40	5884	0.6786	3993	15828	7492	7939	11280	11954	488	2.08
25000	0.60	5829	0.7559	4406	15679	7523	7822	11332	11783	486	2.09
25000	0.80	5950	0.8279	4926	16006	7524	7626	11359	11514	480	2.12
30000	0.40	4884	0.6751	3297	16409	7514	8127	11253	12170	490	2.12
30000	0.60	4878	0.7501	3659	16388	7528	7989	11290	11980	488	2.10
30000	0.80	5031	0.8262	4156	16901	7528	7787	11343	11734	484	2.10
35000	0.40	4015	0.6727	2701	17014	7509	8295	11257	12436	491	2.17
35000	0.60	3986	0.7434	2963	16891	7499	8128	11253	12197	489	2.15
35000	0.80	4200	0.8183	3437	17797	7507	7932	11325	11966	487	2.12
40000	0.40	3109	0.6762	2162	16801	7415	8230	11288	12529	488	2.22
40000	0.60	3083	0.7458	2299	16657	7406	8065	11260	12263	486	2.21
40000	0.80	3237	0.8182	2649	17492	7422	7880	11315	12012	483	2.19

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY + 18F TAMB
MAXIMUM CONTINUOUS RATING

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.20	3.28	1.45	5.43	1.66	12.69	2.20	1.52	1.15	1.55	2.52	1.46
0	0.40	3.24	1.44	5.31	1.65	12.27	2.17	1.48	1.15	1.49	2.46	1.41
0	0.60	3.17	1.43	5.11	1.63	11.63	2.13	1.42	1.13	1.40	2.35	1.34
0	0.80	2.98	1.40	4.72	1.59	10.57	2.06	1.34	1.11	1.29	2.22	1.25
5000	0.20	3.90	1.54	6.52	1.78	15.29	2.36	1.64	1.19	1.74	2.71	1.59
5000	0.40	3.82	1.52	6.34	1.75	14.77	2.32	1.60	1.18	1.68	2.65	1.54
5000	0.60	3.64	1.49	5.98	1.72	13.81	2.26	1.54	1.16	1.58	2.55	1.47
5000	0.80	3.40	1.46	5.50	1.67	12.56	2.18	1.46	1.14	1.47	2.42	1.38
10000	0.20	4.08	1.57	6.88	1.82	16.17	2.43	1.68	1.20	1.81	2.80	1.64
10000	0.40	4.00	1.56	6.68	1.80	15.67	2.39	1.64	1.19	1.76	2.73	1.59
10000	0.60	3.85	1.53	6.37	1.76	14.75	2.32	1.59	1.17	1.66	2.63	1.53
10000	0.80	3.61	1.49	5.90	1.71	13.58	2.24	1.51	1.16	1.55	2.52	1.44
15000	0.20	4.16	1.60	7.10	1.86	16.86	2.49	1.71	1.21	1.87	2.90	1.68
15000	0.40	4.15	1.59	7.01	1.85	16.50	2.46	1.68	1.20	1.82	2.83	1.64
15000	0.60	4.02	1.56	6.70	1.80	15.69	2.39	1.63	1.19	1.74	2.72	1.58
15000	0.80	3.81	1.52	6.28	1.75	14.51	2.30	1.57	1.17	1.63	2.60	1.50
20000	0.20	4.18	1.63	7.19	1.90	17.30	2.55	1.73	1.22	1.91	3.00	1.70
20000	0.40	4.19	1.62	7.15	1.88	17.01	2.52	1.71	1.21	1.87	2.94	1.67
20000	0.60	4.16	1.60	7.02	1.85	16.50	2.46	1.67	1.20	1.81	2.82	1.63
20000	0.80	4.00	1.56	6.63	1.79	15.40	2.37	1.61	1.18	1.71	2.69	1.56
25000	0.20	4.16	1.64	7.25	1.92	17.66	2.60	1.76	1.23	1.94	3.10	1.73
25000	0.40	4.19	1.64	7.22	1.91	17.39	2.58	1.73	1.22	1.90	3.03	1.70
25000	0.60	4.19	1.63	7.15	1.89	16.99	2.53	1.70	1.21	1.86	2.94	1.66
25000	0.80	4.13	1.59	6.94	1.84	16.26	2.44	1.65	1.20	1.79	2.79	1.61
30000	0.40	4.08	1.65	7.15	1.93	17.56	2.62	1.76	1.23	1.93	3.15	1.72
30000	0.60	4.17	1.65	7.19	1.92	17.34	2.58	1.72	1.22	1.90	3.05	1.69
30000	0.80	4.18	1.62	7.10	1.88	16.81	2.52	1.68	1.21	1.84	2.91	1.65
35000	0.40	3.95	1.66	7.07	1.95	17.71	2.67	1.78	1.25	1.96	3.29	1.75
35000	0.60	4.02	1.65	7.06	1.93	17.38	2.63	1.75	1.23	1.91	3.16	1.71
35000	0.80	4.11	1.64	7.10	1.91	17.13	2.58	1.71	1.22	1.88	3.04	1.68
40000	0.40	3.81	1.65	6.87	1.95	17.36	2.68	1.78	1.25	1.94	3.33	1.74
40000	0.60	3.87	1.64	6.86	1.93	17.01	2.63	1.74	1.23	1.89	3.20	1.70
40000	0.80	3.94	1.63	6.86	1.90	16.70	2.57	1.71	1.22	1.85	3.07	1.66

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB
MAXIMUM CLIMB RATING

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.20	12193	0.5903	7198	12193	6932	6904	11128	11084	442	2.24
0	0.40	10522	0.7071	7440	10522	6938	6830	11124	10950	441	2.30
0	0.60	9363	0.8259	7733	9363	6913	6677	11114	10734	433	2.39
0	0.80	8507	0.9493	8075	8507	6850	6450	11138	10487	419	2.50
5000	0.20	11243	0.5828	6552	13508	7079	7175	11092	11243	459	2.16
5000	0.40	9848	0.6898	6794	11833	7076	7088	11105	11124	457	2.22
5000	0.60	8928	0.7955	7102	10727	7027	6907	11107	10917	448	2.30
5000	0.80	8236	0.9012	7423	9896	6933	6643	11122	10656	432	2.42
10000	0.20	10130	0.5799	5875	14722	7232	7464	11089	11445	472	2.11
10000	0.40	9001	0.6727	6055	13081	7199	7343	11098	11320	470	2.15
10000	0.60	8304	0.7696	6390	12067	7112	7119	11072	11081	460	2.23
10000	0.80	7900	0.8663	6844	11481	7045	6874	11108	10838	446	2.32
15000	0.20	8907	0.5795	5161	15768	7327	7706	11110	11685	482	2.08
15000	0.40	8030	0.6679	5363	14215	7327	7616	11102	11540	480	2.11
15000	0.60	7605	0.7494	5699	13463	7254	7398	11110	11331	473	2.16
15000	0.80	7395	0.8369	6189	13091	7137	7096	11103	11039	459	2.24
20000	0.20	7570	0.5791	4383	16450	7315	7845	11079	11882	486	2.07
20000	0.40	6944	0.6640	4611	15090	7344	7784	11091	11756	485	2.09
20000	0.60	6772	0.7393	5006	14717	7362	7656	11111	11555	482	2.11
20000	0.80	6791	0.8162	5543	14758	7283	7384	11138	11292	473	2.17
25000	0.20	6343	0.5775	3663	17063	7333	8026	11030	12072	489	2.07
25000	0.40	5844	0.6599	3857	15720	7328	7927	11044	11947	488	2.08
25000	0.60	5786	0.7353	4254	15562	7360	7812	11097	11778	486	2.10
25000	0.80	6053	0.8111	4910	16282	7422	7680	11189	11577	483	2.11
30000	0.40	4873	0.6556	3195	16371	7363	8136	10998	12152	491	2.11
30000	0.60	4853	0.7288	3537	16303	7369	7988	11038	11967	489	2.09
30000	0.80	5125	0.8068	4135	17217	7414	7836	11167	11801	486	2.10
35000	0.40	4014	0.6534	2622	17008	7362	8316	11007	12434	493	2.15
35000	0.60	4032	0.7244	2921	17066	7398	8200	11036	12232	491	2.14
35000	0.80	4277	0.7980	3413	18123	7436	8035	11121	12017	489	2.11
40000	0.40	3124	0.6563	2056	16879	7289	8275	11061	12557	490	2.21
40000	0.60	3133	0.7278	2280	16932	7319	8153	11070	12330	488	2.20
40000	0.80	3321	0.7998	2656	17946	7357	7988	11147	12104	486	2.18

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB
MAXIMUM CLIMB RATING

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.20	3.54	1.48	5.88	1.71	13.79	2.26	1.57	1.17	1.63	2.60	1.51
0	0.40	3.48	1.47	5.74	1.69	13.31	2.23	1.53	1.16	1.57	2.54	1.46
0	0.60	3.35	1.45	5.45	1.66	12.50	2.18	1.47	1.14	1.47	2.43	1.39
0	0.80	3.15	1.43	5.03	1.62	11.36	2.11	1.38	1.13	1.36	2.30	1.30
5000	0.20	3.81	1.52	6.36	1.76	14.91	2.34	1.62	1.18	1.71	2.68	1.57
5000	0.40	3.74	1.51	6.20	1.74	14.42	2.30	1.58	1.17	1.65	2.62	1.52
5000	0.60	3.57	1.48	5.87	1.71	13.54	2.25	1.52	1.16	1.55	2.52	1.45
5000	0.80	3.32	1.45	5.37	1.66	12.23	2.16	1.44	1.14	1.44	2.38	1.36
10000	0.20	4.04	1.57	6.80	1.81	15.97	2.42	1.66	1.20	1.79	2.78	1.62
10000	0.40	3.95	1.55	6.59	1.79	15.44	2.37	1.63	1.19	1.73	2.69	1.58
10000	0.60	3.78	1.52	6.25	1.75	14.45	2.30	1.57	1.17	1.63	2.60	1.51
10000	0.80	3.55	1.48	5.79	1.70	13.29	2.23	1.50	1.15	1.53	2.48	1.42
15000	0.20	4.15	1.60	7.07	1.86	16.78	2.49	1.70	1.21	1.86	2.88	1.67
15000	0.40	4.12	1.59	6.95	1.84	16.34	2.45	1.67	1.20	1.81	2.80	1.63
15000	0.60	3.99	1.56	6.64	1.80	15.49	2.38	1.62	1.18	1.72	2.70	1.57
15000	0.80	3.77	1.51	6.20	1.74	14.32	2.29	1.56	1.17	1.61	2.58	1.49
20000	0.20	4.18	1.63	7.19	1.90	17.26	2.55	1.73	1.22	1.90	2.99	1.70
20000	0.40	4.19	1.62	7.13	1.88	16.95	2.52	1.70	1.21	1.86	2.91	1.67
20000	0.60	4.15	1.59	6.99	1.85	16.41	2.46	1.66	1.20	1.80	2.81	1.62
20000	0.80	3.99	1.56	6.64	1.80	15.43	2.38	1.61	1.18	1.71	2.68	1.56
25000	0.20	4.16	1.64	7.25	1.92	17.64	2.60	1.76	1.23	1.94	3.09	1.73
25000	0.40	4.19	1.64	7.21	1.91	17.36	2.58	1.73	1.22	1.90	3.01	1.69
25000	0.60	4.19	1.63	7.14	1.89	16.96	2.53	1.69	1.21	1.85	2.92	1.66
25000	0.80	4.16	1.60	7.02	1.85	16.49	2.47	1.66	1.20	1.81	2.82	1.62
30000	0.40	4.12	1.65	7.20	1.93	17.63	2.62	1.75	1.23	1.93	3.13	1.72
30000	0.60	4.19	1.65	7.22	1.92	17.38	2.59	1.72	1.22	1.89	3.03	1.69
30000	0.80	4.20	1.63	7.16	1.89	17.01	2.54	1.69	1.21	1.86	2.94	1.66
35000	0.40	3.98	1.66	7.11	1.95	17.79	2.68	1.78	1.25	1.96	3.27	1.75
35000	0.60	4.05	1.65	7.13	1.94	17.57	2.64	1.75	1.24	1.92	3.17	1.72
35000	0.80	4.16	1.65	7.19	1.92	17.39	2.60	1.73	1.22	1.90	3.06	1.69
40000	0.40	3.83	1.65	6.92	1.95	17.48	2.69	1.78	1.25	1.94	3.33	1.74
40000	0.60	3.90	1.65	6.92	1.94	17.24	2.65	1.75	1.24	1.91	3.22	1.71
40000	0.80	3.98	1.64	6.95	1.92	17.01	2.60	1.72	1.22	1.88	3.11	1.68

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY + 18F TAMB
MAXIMUM CLIMB RATING

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.20	10913	0.5981	6526	10913	6791	6649	11164	10931	424	2.31
0	0.40	9285	0.7267	6747	9285	6804	6585	11144	10784	424	2.38
0	0.60	8139	0.8666	7054	8139	6830	6485	11136	10573	420	2.46
0	0.80	7226	1.0155	7338	7226	6760	6257	11160	10330	406	2.58
5000	0.20	10121	0.5905	5976	12160	6927	6899	11127	11081	442	2.24
5000	0.40	8763	0.7072	6197	10529	6941	6832	11126	10951	441	2.30
5000	0.60	7775	0.8264	6426	9342	6912	6675	11112	10731	433	2.39
5000	0.80	7074	0.9494	6716	8500	6849	6448	11138	10486	419	2.50
10000	0.20	9288	0.5829	5413	13498	7079	7174	11093	11242	459	2.17
10000	0.40	8121	0.6902	5604	11801	7071	7082	11100	11118	456	2.22
10000	0.60	7359	0.7962	5859	10695	7025	6903	11106	10914	448	2.30
10000	0.80	6798	0.9020	6132	9879	6933	6642	11120	10653	432	2.42
15000	0.20	8315	0.5798	4821	14719	7233	7464	11091	11445	472	2.11
15000	0.40	7376	0.6729	4963	13057	7200	7343	11096	11317	470	2.15
15000	0.60	6811	0.7698	5243	12058	7114	7119	11075	11083	460	2.23
15000	0.80	6479	0.8666	5614	11469	7044	6872	11109	10837	446	2.32
20000	0.20	7106	0.5782	4108	15441	7283	7659	11066	11637	479	2.09
20000	0.40	6438	0.6684	4303	13990	7282	7568	11078	11512	477	2.12
20000	0.60	6186	0.7494	4636	13442	7250	7392	11106	11324	472	2.16
20000	0.80	6019	0.8371	5038	13079	7136	7093	11104	11038	459	2.24
25000	0.20	5968	0.5786	3453	16054	7272	7798	11039	11837	482	2.08
25000	0.40	5449	0.6653	3625	14657	7300	7737	11045	11705	481	2.10
25000	0.60	5319	0.7413	3942	14306	7304	7595	11067	11508	478	2.13
25000	0.80	5431	0.8166	4435	14608	7258	7357	11107	11258	471	2.17
30000	0.40	4554	0.6616	3013	15298	7264	7856	11033	11932	484	2.13
30000	0.60	4494	0.7372	3313	15097	7311	7758	11055	11731	481	2.12
30000	0.80	4669	0.8095	3779	15684	7344	7598	11122	11505	478	2.13
35000	0.40	3762	0.6600	2483	15940	7261	8021	11033	12188	486	2.17
35000	0.60	3740	0.7320	2738	15848	7272	7882	11056	11983	484	2.16
35000	0.80	3940	0.8092	3188	16696	7361	7778	11144	11775	481	2.14
40000	0.40	2930	0.6651	1948	15830	7202	7994	11056	12271	484	2.23
40000	0.60	2906	0.7354	2137	15701	7222	7864	11062	12047	482	2.22
40000	0.80	3057	0.8094	2474	16516	7300	7750	11138	11825	478	2.20

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY + 18F TAMB
MAXIMUM CLIMB RATING

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.20	3.28	1.45	5.43	1.66	12.71	2.20	1.52	1.15	1.55	2.52	1.46
0	0.40	3.24	1.44	5.31	1.65	12.28	2.17	1.48	1.15	1.49	2.46	1.41
0	0.60	3.17	1.43	5.11	1.63	11.63	2.13	1.42	1.13	1.40	2.35	1.34
0	0.80	2.98	1.40	4.72	1.59	10.57	2.06	1.34	1.11	1.29	2.22	1.25
5000	0.20	3.53	1.48	5.87	1.71	13.76	2.26	1.57	1.17	1.62	2.60	1.51
5000	0.40	3.49	1.47	5.74	1.69	13.32	2.23	1.53	1.16	1.57	2.54	1.46
5000	0.60	3.35	1.45	5.44	1.66	12.48	2.18	1.47	1.14	1.47	2.43	1.39
5000	0.80	3.15	1.42	5.02	1.62	11.35	2.11	1.38	1.13	1.36	2.30	1.30
10000	0.20	3.80	1.52	6.36	1.76	14.90	2.34	1.62	1.18	1.71	2.68	1.57
10000	0.40	3.73	1.51	6.19	1.74	14.40	2.30	1.58	1.17	1.65	2.62	1.52
10000	0.60	3.57	1.48	5.86	1.71	13.52	2.24	1.52	1.16	1.55	2.52	1.45
10000	0.80	3.32	1.45	5.36	1.66	12.22	2.16	1.44	1.14	1.43	2.38	1.36
15000	0.20	4.04	1.57	6.80	1.81	15.97	2.42	1.66	1.20	1.79	2.78	1.62
15000	0.40	3.95	1.55	6.59	1.79	15.43	2.37	1.63	1.19	1.73	2.69	1.58
15000	0.60	3.78	1.52	6.25	1.75	14.45	2.30	1.57	1.17	1.63	2.60	1.51
15000	0.80	3.55	1.48	5.79	1.70	13.29	2.23	1.50	1.15	1.52	2.48	1.42
20000	0.20	4.11	1.59	6.99	1.85	16.55	2.48	1.69	1.21	1.84	2.86	1.65
20000	0.40	4.08	1.58	6.88	1.83	16.15	2.44	1.66	1.20	1.79	2.79	1.62
20000	0.60	3.99	1.56	6.64	1.80	15.48	2.38	1.62	1.18	1.72	2.69	1.57
20000	0.80	3.76	1.51	6.20	1.74	14.31	2.29	1.55	1.17	1.61	2.58	1.49
25000	0.20	4.13	1.62	7.09	1.89	16.99	2.54	1.71	1.21	1.88	2.96	1.68
25000	0.40	4.14	1.61	7.04	1.87	16.67	2.51	1.68	1.21	1.83	2.89	1.64
25000	0.60	4.09	1.59	6.87	1.84	16.12	2.45	1.65	1.19	1.78	2.79	1.60
25000	0.80	3.98	1.55	6.60	1.79	15.32	2.37	1.61	1.18	1.70	2.68	1.55
30000	0.40	4.06	1.63	7.02	1.90	16.93	2.56	1.71	1.22	1.87	3.01	1.67
30000	0.60	4.12	1.62	7.00	1.88	16.61	2.51	1.67	1.20	1.82	2.90	1.63
30000	0.80	4.08	1.59	6.86	1.84	16.07	2.45	1.64	1.19	1.77	2.78	1.60
35000	0.40	3.94	1.64	6.94	1.92	17.12	2.62	1.74	1.23	1.90	3.15	1.70
35000	0.60	4.01	1.63	6.95	1.91	16.84	2.58	1.71	1.22	1.86	3.04	1.67
35000	0.80	4.07	1.62	6.96	1.88	16.58	2.52	1.68	1.21	1.82	2.93	1.64
40000	0.40	3.81	1.63	6.77	1.92	16.84	2.63	1.74	1.23	1.88	3.20	1.69
40000	0.60	3.66	1.62	6.75	1.90	16.52	2.58	1.70	1.22	1.84	3.08	1.66
40000	0.80	3.91	1.61	6.73	1.87	16.20	2.52	1.67	1.21	1.80	2.97	1.63

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB
MAXIMUM CRUISE RATING

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
20000	0.65	6189	0.7523	4656	13449	7110	7351	10906	11277	472	2.17
20000	0.70	6147	0.7750	4764	13357	7085	7281	10906	11207	468	2.19
20000	0.75	6111	0.7964	4866	13279	7051	7198	10910	11138	465	2.21
20000	0.80	6080	0.8175	4970	13213	7023	7120	10913	11064	461	2.24
20000	0.85	6041	0.8403	5077	13129	6996	7041	10932	11003	457	2.26
25000	0.65	5428	0.7428	4032	14600	7209	7607	10914	11516	479	2.13
25000	0.70	5457	0.7605	4150	14678	7200	7551	10937	11470	478	2.14
25000	0.75	5505	0.7772	4278	14807	7194	7496	10964	11423	476	2.15
25000	0.80	5546	0.7970	4420	14918	7186	7435	10991	11372	474	2.16
25000	0.85	5542	0.8240	4566	14966	7153	7347	10955	11252	472	2.17
30000	0.65	4604	0.7371	3394	15469	7213	7775	10892	11740	483	2.11
30000	0.70	4646	0.7534	3500	15610	7223	7737	10907	11684	482	2.11
30000	0.75	4703	0.7699	3621	15800	7231	7695	10921	11622	481	2.12
30000	0.80	4763	0.7923	3774	16003	7252	7664	10953	11575	480	2.12
30000	0.85	4829	0.8128	3925	16224	7256	7613	10976	11516	479	2.13
35000	0.65	4089	0.7406	3028	17325	7413	8166	11056	12163	491	2.13
35000	0.70	4149	0.7579	3145	17582	7422	8129	11075	12129	490	2.13
35000	0.75	4199	0.7795	3273	17792	7431	8085	11098	12075	490	2.12
35000	0.80	4277	0.7980	3413	18122	7436	8035	11122	12017	489	2.11
35000	0.85	4389	0.8125	3566	18596	7442	7982	11148	11958	489	2.10
40000	0.65	3175	0.7435	2360	17154	7330	8117	11084	12275	468	2.20
40000	0.70	3222	0.7601	2449	17409	7341	8080	11102	12219	487	2.19
40000	0.75	3264	0.7805	2548	17640	7349	8036	11129	12169	487	2.18
40000	0.80	3321	0.7998	2656	17947	7356	7988	11147	12104	486	2.18
40000	0.85	3409	0.8141	2775	18420	7364	7939	11173	12045	485	2.17

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB
MAXIMUM CRUISE RATING

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
20000	0.65	3.97	1.55	6.60	1.79	15.34	2.37	1.61	1.18	1.70	2.67	1.55
20000	0.70	3.93	1.54	6.50	1.78	15.06	2.35	1.59	1.18	1.68	2.65	1.54
20000	0.75	3.86	1.53	6.37	1.76	14.73	2.33	1.58	1.17	1.65	2.62	1.52
20000	0.80	3.79	1.52	6.24	1.75	14.42	2.31	1.56	1.17	1.62	2.59	1.49
20000	0.85	3.71	1.51	6.11	1.73	14.09	2.28	1.54	1.16	1.59	2.56	1.47
25000	0.65	4.10	1.59	6.90	1.64	16.17	2.45	1.65	1.19	1.78	2.78	1.60
25000	0.70	4.07	1.58	6.82	1.83	15.98	2.43	1.64	1.19	1.76	2.75	1.59
25000	0.75	4.03	1.57	6.74	1.82	15.78	2.41	1.63	1.19	1.74	2.73	1.58
25000	0.80	4.00	1.56	6.66	1.80	15.58	2.39	1.62	1.19	1.72	2.70	1.57
25000	0.85	3.98	1.55	6.60	1.79	15.31	2.37	1.61	1.18	1.70	2.67	1.55
30000	0.65	4.15	1.62	7.06	1.88	16.73	2.52	1.68	1.20	1.83	2.89	1.64
30000	0.70	4.14	1.61	7.02	1.87	16.58	2.50	1.67	1.20	1.81	2.86	1.63
30000	0.75	4.13	1.60	6.98	1.86	16.44	2.49	1.66	1.20	1.80	2.83	1.62
30000	0.80	4.12	1.60	6.95	1.85	16.33	2.47	1.65	1.20	1.79	2.81	1.61
30000	0.85	4.10	1.59	6.89	1.84	16.16	2.45	1.64	1.19	1.78	2.78	1.60
35000	0.65	4.08	1.65	7.15	1.94	17.53	2.63	1.75	1.23	1.92	3.15	1.71
35000	0.70	4.10	1.65	7.16	1.93	17.49	2.62	1.74	1.23	1.91	3.12	1.70
35000	0.75	4.13	1.65	7.17	1.93	17.44	2.61	1.73	1.23	1.90	3.09	1.70
35000	0.80	4.16	1.65	7.19	1.92	17.39	2.60	1.73	1.22	1.90	3.06	1.69
35000	0.85	4.19	1.65	7.21	1.92	17.34	2.58	1.72	1.22	1.89	3.03	1.68
40000	0.65	3.91	1.65	6.93	1.93	17.18	2.64	1.74	1.23	1.90	3.20	1.70
40000	0.70	3.94	1.64	6.94	1.93	17.13	2.63	1.74	1.23	1.89	3.17	1.69
40000	0.75	3.95	1.64	6.94	1.92	17.07	2.62	1.73	1.23	1.88	3.14	1.69
40000	0.80	3.98	1.64	6.95	1.92	17.01	2.60	1.72	1.22	1.88	3.11	1.68
40000	0.85	4.00	1.64	6.96	1.91	16.95	2.59	1.72	1.22	1.87	3.08	1.67

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY + 18F TAMB
MAXIMUM CRUISE RATING

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
20000	0.65	5488	0.7743	4250	11926	6973	7069	10891	11041	458	2.25
20000	0.70	5411	0.7984	4320	11759	6950	7002	10903	10985	454	2.27
20000	0.75	5342	0.8229	4396	11609	6936	6943	10916	10926	450	2.30
20000	0.80	5291	0.8472	4482	11497	6924	6883	10919	10854	446	2.32
20000	0.85	5232	0.8706	4555	11369	6897	6806	10933	10789	442	2.35
25000	0.65	4873	0.7567	3687	13107	7063	7301	10870	11237	468	2.18
25000	0.70	4847	0.7790	3775	13037	7039	7231	10881	11179	465	2.20
25000	0.75	4851	0.7993	3877	13049	7021	7166	10895	11120	462	2.22
25000	0.80	4865	0.8190	3984	13087	7011	7106	10909	11058	460	2.24
25000	0.85	4861	0.8411	4088	13075	6990	7034	10931	11000	456	2.27
30000	0.65	4181	0.7464	3121	14047	7125	7517	10869	11467	474	2.16
30000	0.70	4211	0.7631	3213	14146	7127	7473	10894	11422	473	2.16
30000	0.75	4232	0.7817	3308	14216	7118	7414	10919	11374	471	2.17
30000	0.80	4263	0.8003	3411	14321	7091	7335	10888	11263	469	2.18
30000	0.85	4277	0.8271	3537	14368	7076	7267	10910	11205	466	2.20
35000	0.65	3782	0.7495	2834	16026	7293	7859	11076	11936	484	2.16
35000	0.70	3839	0.7660	2941	16267	7316	7835	11097	11885	483	2.15
35000	0.75	3899	0.7845	3059	16520	7338	7808	11120	11831	482	2.14
35000	0.80	3940	0.8092	3188	16696	7361	7778	11144	11775	481	2.14
35000	0.85	4033	0.8260	3331	17088	7364	7746	11170	11717	481	2.13
40000	0.65	2933	0.7525	2207	15847	7239	7838	11076	11993	481	2.22
40000	0.70	2971	0.7685	2283	16052	7256	7808	11092	11935	480	2.21
40000	0.75	3020	0.7861	2374	16320	7278	7780	11115	11882	479	2.21
40000	0.80	3056	0.8094	2474	16514	7301	7751	11139	11826	478	2.20
40000	0.85	3123	0.8274	2584	16876	7323	7716	11166	11768	478	2.20

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY + 18F TAMB
MAXIMUM CRUISE RATING

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
20000	0.65	3.74	1.51	6.16	1.74	14.22	2.29	1.55	1.17	1.61	2.58	1.49
20000	0.70	3.67	1.50	6.04	1.72	13.93	2.27	1.54	1.16	1.58	2.55	1.47
20000	0.75	3.61	1.49	5.92	1.71	13.65	2.26	1.52	1.16	1.55	2.52	1.45
20000	0.80	3.56	1.48	5.81	1.70	13.33	2.24	1.50	1.15	1.53	2.49	1.42
20000	0.85	3.48	1.47	5.66	1.69	12.97	2.21	1.48	1.15	1.50	2.45	1.40
25000	0.65	3.92	1.55	6.51	1.78	15.10	2.36	1.60	1.18	1.68	2.66	1.54
25000	0.70	3.87	1.54	6.40	1.77	14.83	2.34	1.58	1.18	1.66	2.64	1.52
25000	0.75	3.82	1.53	6.31	1.76	14.58	2.32	1.57	1.17	1.63	2.61	1.51
25000	0.80	3.77	1.52	6.21	1.74	14.33	2.30	1.55	1.17	1.61	2.58	1.49
25000	0.85	3.70	1.50	6.09	1.73	14.05	2.28	1.54	1.16	1.59	2.56	1.47
30000	0.65	4.01	1.58	6.73	1.83	15.77	2.43	1.63	1.19	1.74	2.76	1.58
30000	0.70	3.99	1.57	6.67	1.82	15.63	2.41	1.62	1.19	1.73	2.73	1.57
30000	0.75	3.96	1.56	6.59	1.80	15.42	2.39	1.61	1.18	1.71	2.70	1.55
30000	0.80	3.94	1.55	6.54	1.79	15.19	2.37	1.60	1.18	1.69	2.67	1.54
30000	0.85	3.89	1.54	6.45	1.78	14.93	2.35	1.58	1.18	1.66	2.65	1.52
35000	0.65	4.03	1.63	6.95	1.90	16.78	2.56	1.70	1.21	1.85	3.01	1.66
35000	0.70	4.04	1.63	6.96	1.89	16.72	2.55	1.69	1.21	1.84	2.99	1.65
35000	0.75	4.06	1.62	6.96	1.89	16.65	2.54	1.68	1.21	1.83	2.96	1.64
35000	0.80	4.07	1.62	6.96	1.88	16.58	2.52	1.68	1.21	1.82	2.93	1.64
35000	0.85	4.09	1.61	6.96	1.87	16.51	2.51	1.67	1.20	1.81	2.90	1.63
40000	0.65	3.87	1.62	6.75	1.89	16.44	2.57	1.70	1.21	1.83	3.05	1.65
40000	0.70	3.89	1.61	6.74	1.89	16.36	2.55	1.69	1.21	1.82	3.02	1.64
40000	0.75	3.90	1.61	6.74	1.88	16.28	2.54	1.68	1.21	1.81	2.99	1.63
40000	0.80	3.91	1.61	6.73	1.87	16.20	2.52	1.67	1.21	1.80	2.96	1.62
40000	0.85	3.92	1.60	6.73	1.86	16.12	2.51	1.67	1.20	1.79	2.94	1.62

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
0	0.00	16600	0.4971	8251	16600	7303	7303	11329	11329	464	2.12
0	0.00	16154	0.4943	7984	16154	7211	7211	11273	11273	459	2.14
0	0.00	14736	0.4845	7139	14736	6928	6928	11113	11113	442	2.22
0	0.00	13323	0.4745	6322	13323	6673	6673	10971	10971	424	2.28
0	0.00	11716	0.4689	5494	11716	6358	6358	10817	10817	400	2.37
0	0.00	10319	0.4637	4784	10319	6058	6058	10667	10667	376	2.43
0	0.00	9069	0.4624	4193	9069	5789	5789	10508	10508	355	2.48
0	0.00	7822	0.4669	3652	7822	5509	5509	10305	10305	330	2.49
0	0.00	6418	0.4707	3021	6418	5115	5115	10041	10041	301	2.54
0	0.00	5673	0.4824	2447	5073	4676	4676	9657	9657	270	2.60
0	0.20	13995	0.5978	8366	13995	7312	7283	11350	11305	465	2.14
0	0.20	13547	0.5958	8071	13547	7208	7179	11284	11239	459	2.16
0	0.20	12210	0.5905	7210	12210	6935	6908	11130	11085	442	2.24
0	0.20	10902	0.5856	6383	10902	6677	6651	10985	10942	424	2.31
0	0.20	9437	0.5885	5553	9437	6372	6346	10834	10791	401	2.39
0	0.20	8206	0.5924	4861	8206	6087	6063	10682	10640	380	2.47
0	0.20	7183	0.5992	4303	7183	5837	5814	10517	10475	360	2.51
0	0.20	6093	0.6145	3744	6093	5557	5535	10321	10280	338	2.55
0	0.20	4921	0.6361	3130	4921	5214	5194	10063	10023	312	2.60
0	0.20	3728	0.6789	2531	3728	4758	4739	9660	9641	281	2.69
0	0.40	12336	0.7050	8696	12336	7294	7180	11358	11181	462	2.19
0	0.40	11965	0.7052	8438	11965	7220	7107	11304	11127	458	2.21
0	0.40	10742	0.7068	7593	10742	6984	6875	11147	10973	443	2.28
0	0.40	9487	0.7102	6738	9487	6733	6628	11000	10828	427	2.37
0	0.40	8321	0.7215	6004	8321	6504	6403	10851	10682	410	2.43
0	0.40	6973	0.7455	5198	6973	6189	6092	10706	10539	388	2.53
0	0.40	6121	0.7609	4657	6121	5994	5900	10555	10390	374	2.59
0	0.40	5210	0.7823	4075	5210	5748	5658	10366	10204	357	2.66
0	0.40	4187	0.8226	3444	4187	5492	5406	10133	9974	336	2.70
0	0.40	3073	0.9109	2799	3073	5028	4950	9765	9612	309	2.88
0	0.60	11396	0.8080	9208	11396	7248	7000	11368	10980	453	2.27
0	0.60	11139	0.8095	9017	11139	7207	6961	11337	10950	451	2.28
0	0.60	9922	0.8192	8126	9922	7008	6769	11191	10809	439	2.36
0	0.60	8748	0.8360	7313	8748	6821	6588	11041	10664	427	2.43
0	0.60	7614	0.8611	6557	7614	6628	6401	10894	10522	414	2.49
0	0.60	6351	0.9026	5733	6351	6353	6136	10756	10388	397	2.59
0	0.60	5454	0.9410	5132	5454	6175	5964	10615	10252	384	2.65
0	0.60	4555	0.9965	4539	4555	5964	5760	10437	10081	370	2.74
0	0.60	3597	1.0917	3927	3597	5725	5529	10205	9856	354	2.83
0	0.80	9482	0.9278	8798	9482	6991	6582	11257	10599	428	2.45
0	0.80	8217	0.9570	7864	8217	6808	6410	11099	10450	416	2.51
0	0.80	6962	1.0073	7013	6962	6606	6219	10952	10312	404	2.60
0	0.80	5858	1.0760	6303	5858	6418	6042	10812	10180	392	2.67
0	0.80	4917	1.1539	5674	4917	6259	5693	10684	10060	381	2.74
0	0.80	4003	1.2775	5114	4003	6086	5730	10519	9904	371	2.83

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
0	0.00	3.93	1.54	6.60	1.78	15.48	2.37	1.65	1.19	1.76	2.73	1.61
0	0.00	3.84	1.53	6.44	1.77	15.10	2.35	1.64	1.19	1.73	2.71	1.59
0	0.00	3.56	1.49	5.95	1.72	13.95	2.28	1.59	1.17	1.65	2.63	1.53
0	0.00	3.30	1.45	5.49	1.67	12.86	2.22	1.53	1.16	1.57	2.54	1.47
0	0.00	2.99	1.41	4.96	1.62	11.60	2.15	1.47	1.14	1.48	2.47	1.41
0	0.00	2.73	1.37	4.49	1.58	10.51	2.09	1.41	1.13	1.41	2.40	1.35
0	0.00	2.51	1.34	4.11	1.54	9.58	2.03	1.36	1.11	1.34	2.33	1.30
0	0.00	2.32	1.30	3.76	1.50	8.69	1.97	1.31	1.10	1.29	2.26	1.26
0	0.00	2.06	1.26	3.31	1.44	7.63	1.89	1.26	1.09	1.23	2.18	1.21
0	0.00	1.82	1.21	2.88	1.38	6.50	1.80	1.21	1.07	1.17	2.10	1.16
0	0.20	3.91	1.54	6.53	1.78	15.32	2.36	1.64	1.19	1.74	2.71	1.59
0	0.20	3.81	1.52	6.36	1.76	14.93	2.33	1.62	1.18	1.71	2.68	1.57
0	0.20	3.54	1.48	5.89	1.71	13.80	2.27	1.57	1.17	1.63	2.60	1.51
0	0.20	3.28	1.45	5.43	1.67	12.72	2.20	1.52	1.15	1.55	2.52	1.46
0	0.20	2.98	1.41	4.92	1.62	11.50	2.14	1.46	1.14	1.46	2.44	1.39
0	0.20	2.73	1.37	4.48	1.58	10.46	2.08	1.40	1.13	1.39	2.37	1.34
0	0.20	2.54	1.34	4.14	1.54	9.60	2.03	1.35	1.11	1.33	2.31	1.29
0	0.20	2.34	1.31	3.79	1.50	8.72	1.97	1.31	1.10	1.27	2.25	1.25
0	0.20	2.11	1.27	3.38	1.45	7.74	1.89	1.26	1.09	1.21	2.16	1.20
0	0.20	1.86	1.22	2.93	1.39	6.57	1.80	1.20	1.07	1.16	2.08	1.15
0	0.40	3.83	1.52	6.35	1.76	14.80	2.32	1.60	1.18	1.68	2.65	1.54
0	0.40	3.76	1.51	6.23	1.74	14.50	2.30	1.59	1.17	1.66	2.63	1.53
0	0.40	3.53	1.46	5.82	1.70	13.50	2.24	1.54	1.16	1.58	2.55	1.47
0	0.40	3.28	1.44	5.38	1.66	12.45	2.19	1.49	1.15	1.50	2.47	1.42
0	0.40	3.07	1.42	5.01	1.63	11.55	2.14	1.44	1.14	1.43	2.40	1.37
0	0.40	2.70	1.38	4.52	1.58	10.42	2.08	1.38	1.12	1.35	2.33	1.31
0	0.40	2.63	1.35	4.24	1.55	9.72	2.03	1.34	1.11	1.30	2.26	1.27
0	0.40	2.44	1.32	3.91	1.51	8.89	1.97	1.30	1.10	1.24	2.19	1.22
0	0.40	2.27	1.29	3.56	1.47	8.04	1.91	1.25	1.08	1.18	2.10	1.17
0	0.40	2.00	1.24	3.12	1.41	6.86	1.83	1.19	1.07	1.12	2.03	1.13
0	0.60	3.67	1.50	6.04	1.72	13.95	2.26	1.54	1.16	1.59	2.56	1.48
0	0.60	3.63	1.49	5.97	1.71	13.78	2.25	1.53	1.16	1.58	2.55	1.47
0	0.60	3.44	1.46	5.61	1.68	12.92	2.21	1.49	1.15	1.51	2.47	1.41
0	0.60	3.26	1.44	5.28	1.65	12.08	2.16	1.44	1.14	1.44	2.39	1.36
0	0.60	3.10	1.42	4.97	1.62	11.29	2.11	1.39	1.13	1.37	2.31	1.31
0	0.60	2.85	1.39	4.55	1.58	10.31	2.06	1.34	1.11	1.30	2.24	1.26
0	0.60	2.71	1.37	4.29	1.55	9.64	2.02	1.30	1.10	1.25	2.18	1.22
0	0.60	2.55	1.34	4.00	1.52	8.90	1.97	1.27	1.09	1.19	2.12	1.18
0	0.60	2.39	1.32	3.72	1.49	8.14	1.92	1.22	1.08	1.13	2.04	1.14
0	0.80	3.27	1.44	5.25	1.64	11.95	2.14	1.42	1.13	1.41	2.36	1.34
0	0.80	3.12	1.42	4.97	1.62	11.19	2.10	1.37	1.12	1.35	2.28	1.29
0	0.80	2.95	1.40	4.66	1.59	10.42	2.06	1.33	1.11	1.28	2.21	1.24
0	0.80	2.80	1.38	4.40	1.56	9.76	2.02	1.29	1.10	1.22	2.15	1.19
0	0.80	2.67	1.36	4.17	1.54	9.19	1.99	1.25	1.09	1.17	2.09	1.15
0	0.80	2.56	1.34	3.96	1.52	8.61	1.95	1.21	1.09	1.12	2.04	1.11

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE 100 PERCENT RAM RECOVERY
NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
5000	0.00	14705	0.4997	7348	17668	7424	7555	11333	11533	475	2.08
5000	0.00	14350	0.4944	7095	17242	7329	7458	11253	11451	471	2.10
5000	0.00	13433	0.4834	6494	16140	7087	7212	11084	11280	459	2.14
5000	0.00	12200	0.4736	5778	14658	6796	6916	10920	11113	441	2.22
5000	0.00	10955	0.4636	5079	13163	6529	6644	10773	10963	422	2.29
5000	0.00	9581	0.4584	4392	11512	6208	6317	10618	10805	397	2.38
5000	0.00	8372	0.4534	3796	10059	5900	6004	10460	10644	372	2.44
5000	0.00	7149	0.4541	3246	8589	5585	5684	10267	10448	346	2.48
5000	0.00	5852	0.4596	2689	7032	5220	5312	10000	10176	315	2.51
5000	0.00	4592	0.4680	2148	5517	4741	4825	9620	9790	280	2.58
5000	0.20	12502	0.5964	7456	15021	7426	7527	11337	11491	475	2.10
5000	0.20	12174	0.5918	7204	14627	7335	7435	11262	11416	471	2.11
5000	0.20	11267	0.5832	6571	13538	7087	7184	11097	11248	459	2.16
5000	0.20	10121	0.5777	5847	12160	6810	6902	10940	11089	442	2.24
5000	0.20	8956	0.5733	5134	10761	6537	6626	10792	10939	423	2.32
5000	0.20	7710	0.5770	4448	9264	6227	6312	10641	10786	399	2.40
5000	0.20	6644	0.5803	3855	7983	5929	6010	10483	10626	376	2.48
5000	0.20	5699	0.5897	3361	6848	5658	5735	10277	10417	354	2.53
5000	0.20	4572	0.6112	2794	5493	5316	5389	10025	10161	325	2.56
5000	0.20	3418	0.6474	2213	4107	4821	4886	9647	9778	291	2.66
5000	0.40	11265	0.6922	7797	13535	7419	7432	11373	11392	473	2.13
5000	0.40	10912	0.6880	7507	13111	7330	7342	11294	11314	470	2.15
5000	0.40	9962	0.6898	6872	11969	7102	7114	11124	11144	458	2.21
5000	0.40	8933	0.6915	6177	10733	6868	6879	10969	10988	444	2.28
5000	0.40	7876	0.6952	5475	9463	6617	6629	10816	10835	427	2.37
5000	0.40	6848	0.7079	4847	8227	6380	6391	10672	10691	409	2.44
5000	0.40	5705	0.7323	4177	6854	6059	6070	10516	10534	387	2.54
5000	0.40	4883	0.7506	3665	5867	5832	5842	10326	10344	370	2.60
5000	0.40	3833	0.7871	3017	4605	5490	5500	10077	10095	344	2.69
5000	0.60	10628	0.7841	8333	12769	7364	7238	11356	11161	466	2.19
5000	0.60	10330	0.7846	8105	12411	7292	7167	11304	11110	462	2.21
5000	0.60	9274	0.7925	7350	11143	7088	6967	11155	10964	452	2.28
5000	0.60	8263	0.8019	6626	9929	6892	6774	11011	10822	440	2.35
5000	0.60	7272	0.8192	5957	8737	6705	6590	10857	10671	428	2.43
5000	0.60	6313	0.8441	5329	7586	6512	6401	10716	10533	414	2.49
5000	0.60	5222	0.8869	4631	6274	6230	6123	10572	10391	396	2.59
5000	0.60	4332	0.9356	4053	5205	6019	5916	10398	10219	381	2.67
5000	0.60	3354	1.0221	3428	4031	5733	5635	10153	9979	362	2.79
5000	0.80	10210	0.8795	8979	12267	7268	6964	11401	10924	452	2.29
5000	0.80	9918	0.8821	8749	11916	7224	6922	11351	10877	449	2.30
5000	0.80	8819	0.8941	7884	10596	7038	6744	11203	10735	438	2.38
5000	0.80	7800	0.9107	7103	9372	6860	6573	11059	10596	427	2.45
5000	0.80	6817	0.9379	6393	8190	6691	6411	10916	10460	416	2.51
5000	0.80	5789	0.9867	5712	6955	6494	6222	10777	10326	404	2.60
5000	0.80	4840	1.0580	5121	5815	6305	6041	10635	10190	392	2.67
5000	0.80	3899	1.1605	4525	4685	6120	5864	10478	10040	379	2.75

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STANDARD DAY TAMB

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
5000	0.00	4.09	1.58	6.92	1.83	16.32	2.44	1.69	1.20	1.83	2.83	1.65
5000	0.00	4.04	1.57	6.81	1.81	16.01	2.42	1.67	1.20	1.80	2.79	1.63
5000	0.00	3.84	1.53	6.44	1.77	15.11	2.35	1.64	1.19	1.73	2.71	1.59
5000	0.00	3.55	1.48	5.93	1.71	13.90	2.28	1.58	1.17	1.64	2.63	1.53
5000	0.00	3.28	1.45	5.44	1.67	12.75	2.21	1.53	1.16	1.56	2.54	1.47
5000	0.00	2.95	1.40	4.90	1.62	11.45	2.15	1.46	1.14	1.47	2.46	1.40
5000	0.00	2.68	1.36	4.41	1.57	10.32	2.08	1.40	1.13	1.39	2.38	1.34
5000	0.00	2.44	1.33	3.97	1.52	9.25	2.01	1.34	1.11	1.32	2.30	1.29
5000	0.00	2.18	1.28	3.52	1.47	8.11	1.93	1.28	1.09	1.25	2.21	1.23
5000	0.00	1.90	1.23	3.02	1.40	6.86	1.83	1.23	1.08	1.19	2.13	1.18
5000	0.20	4.08	1.57	6.88	1.82	16.18	2.43	1.68	1.20	1.81	2.80	1.64
5000	0.20	4.02	1.56	6.76	1.81	15.87	2.41	1.66	1.19	1.78	2.77	1.62
5000	0.20	3.81	1.52	6.37	1.76	14.94	2.34	1.62	1.18	1.71	2.68	1.57
5000	0.20	3.53	1.48	5.86	1.71	13.78	2.27	1.57	1.17	1.62	2.60	1.51
5000	0.20	3.26	1.44	5.39	1.66	12.62	2.20	1.51	1.15	1.54	2.51	1.45
5000	0.20	2.95	1.40	4.87	1.61	11.38	2.14	1.45	1.14	1.45	2.43	1.39
5000	0.20	2.69	1.36	4.41	1.57	10.28	2.07	1.39	1.12	1.37	2.36	1.33
5000	0.20	2.48	1.33	4.04	1.53	9.33	2.01	1.34	1.11	1.31	2.29	1.28
5000	0.20	2.24	1.29	3.61	1.48	8.28	1.94	1.28	1.09	1.24	2.19	1.22
5000	0.20	1.94	1.23	3.07	1.41	6.94	1.83	1.22	1.08	1.18	2.10	1.17
5000	0.40	4.01	1.56	6.72	1.80	15.75	2.39	1.65	1.19	1.76	2.74	1.60
5000	0.40	3.95	1.55	6.59	1.78	15.44	2.37	1.63	1.19	1.73	2.70	1.58
5000	0.40	3.76	1.51	6.24	1.74	14.53	2.31	1.59	1.17	1.66	2.63	1.53
5000	0.40	3.53	1.48	5.83	1.70	13.53	2.25	1.54	1.16	1.58	2.55	1.47
5000	0.40	3.28	1.45	5.38	1.66	12.46	2.19	1.49	1.15	1.50	2.47	1.42
5000	0.40	3.06	1.42	4.99	1.63	11.51	2.14	1.43	1.13	1.43	2.39	1.36
5000	0.40	2.76	1.37	4.49	1.58	10.33	2.07	1.37	1.12	1.34	2.32	1.30
5000	0.40	2.58	1.35	4.16	1.54	9.51	2.02	1.33	1.11	1.28	2.24	1.25
5000	0.40	2.33	1.31	3.70	1.49	8.38	1.94	1.27	1.09	1.20	2.14	1.19
5000	0.60	3.89	1.54	6.44	1.77	14.92	2.33	1.59	1.18	1.68	2.65	1.54
5000	0.60	3.83	1.52	6.33	1.75	14.65	2.31	1.58	1.17	1.65	2.63	1.52
5000	0.60	3.64	1.49	5.98	1.72	13.80	2.26	1.53	1.16	1.58	2.55	1.47
5000	0.60	3.44	1.47	5.62	1.68	12.95	2.21	1.49	1.15	1.51	2.47	1.41
5000	0.60	3.26	1.44	5.29	1.65	12.09	2.16	1.44	1.14	1.44	2.39	1.36
5000	0.60	3.09	1.42	4.97	1.62	11.30	2.12	1.39	1.13	1.37	2.31	1.31
5000	0.60	2.83	1.38	4.53	1.58	10.26	2.06	1.34	1.11	1.29	2.24	1.26
5000	0.60	2.66	1.36	4.21	1.55	9.46	2.01	1.29	1.10	1.23	2.16	1.21
5000	0.60	2.45	1.33	3.84	1.51	8.49	1.95	1.24	1.09	1.16	2.08	1.16
5000	0.80	3.64	1.49	5.96	1.71	13.75	2.25	1.53	1.16	1.57	2.53	1.46
5000	0.80	3.60	1.49	5.88	1.71	13.53	2.24	1.51	1.16	1.55	2.51	1.44
5000	0.80	3.42	1.46	5.55	1.67	12.68	2.19	1.46	1.14	1.47	2.43	1.39
5000	0.80	3.26	1.44	5.24	1.64	11.90	2.14	1.42	1.13	1.41	2.35	1.34
5000	0.80	3.12	1.42	4.97	1.62	11.20	2.10	1.37	1.12	1.34	2.28	1.29
5000	0.80	2.95	1.40	4.66	1.59	10.44	2.06	1.33	1.11	1.28	2.21	1.24
5000	0.80	2.80	1.38	4.39	1.57	9.76	2.02	1.28	1.10	1.22	2.15	1.19
5000	0.80	2.65	1.36	4.13	1.54	9.08	1.98	1.24	1.09	1.16	2.08	1.14

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ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
10000	0.00	12784	0.5033	6433	18578	7479	7750	11338	11749	483	2.07
10000	0.00	12464	0.4942	6159	18112	7391	7659	11231	11638	480	2.07
10000	0.00	11850	0.4831	5725	17221	7201	7462	11061	11462	472	2.10
10000	0.00	11065	0.4721	5224	16080	6952	7204	10885	11280	459	2.15
10000	0.00	9985	0.4625	4617	14510	6653	6894	10719	11107	440	2.23
10000	0.00	8916	0.4531	4040	12957	6376	6607	10570	10953	419	2.30
10000	0.00	7746	0.4475	3466	11257	6046	6265	10406	10783	393	2.39
10000	0.00	6562	0.4431	2907	9536	5687	5893	10220	10590	363	2.46
10000	0.00	5333	0.4473	2385	7750	5302	5494	9960	10322	329	2.49
10000	0.00	4132	0.4547	1878	6004	4808	4982	9586	9933	292	2.55
10000	0.20	10974	0.5959	6539	15947	7469	7730	11343	11708	483	2.08
10000	0.20	10663	0.5880	6270	15495	7408	7646	11239	11601	480	2.08
10000	0.20	10062	0.5789	5825	14623	7211	7442	11070	11426	472	2.11
10000	0.20	9279	0.5697	5286	13484	6951	7174	10900	11250	459	2.17
10000	0.20	8280	0.5647	4676	12033	6669	6884	10740	11085	441	2.24
10000	0.20	7266	0.5616	4081	10562	6382	6587	10591	10931	420	2.33
10000	0.20	6222	0.5649	3515	9042	6069	6264	10430	10765	395	2.42
10000	0.20	5172	0.5704	2950	7516	5709	5893	10243	10572	367	2.50
10000	0.20	4163	0.5897	2455	6050	5356	5528	9972	10293	337	2.55
10000	0.40	10004	0.6866	6868	14538	7521	7671	11361	11589	482	2.10
10000	0.40	9666	0.6816	6588	14047	7411	7560	11262	11488	478	2.11
10000	0.40	9019	0.6730	6069	13106	7204	7348	11105	11328	470	2.15
10000	0.40	8204	0.6747	5535	11922	6972	7112	10932	11151	458	2.21
10000	0.40	7272	0.6767	4921	10569	6717	6852	10775	10991	442	2.29
10000	0.40	6410	0.6810	4365	9315	6473	6603	10616	10829	425	2.38
10000	0.40	5452	0.6971	3800	7923	6198	6323	10464	10674	405	2.46
10000	0.40	4476	0.7224	3234	6505	5875	5993	10278	10484	381	2.56
10000	0.40	3584	0.7505	2690	5209	5553	5665	10020	10221	357	2.66
10000	0.60	9630	0.7687	7402	13995	7489	7496	11406	11415	476	2.14
10000	0.60	9252	0.7667	7093	13445	7376	7382	11296	11306	472	2.16
10000	0.60	8555	0.7680	6570	12432	7177	7183	11123	11133	463	2.21
10000	0.60	7701	0.7752	5970	11192	6975	6981	10973	10982	452	2.28
10000	0.60	6830	0.7845	5357	9925	6773	6778	10828	10838	440	2.35
10000	0.60	5996	0.8019	4808	8714	6586	6591	10676	10685	428	2.43
10000	0.60	5163	0.8283	4276	7503	6385	6390	10527	10536	413	2.49
10000	0.60	4110	0.8799	3616	5973	6063	6068	10349	10358	392	2.61
10000	0.60	3155	0.9538	3009	4585	5770	5775	10098	10106	371	2.74
10000	0.80	9457	0.8542	8078	13743	7362	7183	11378	11102	464	2.22
10000	0.80	9127	0.8551	7804	13263	7289	7111	11321	11046	460	2.24
10000	0.80	8239	0.8626	7107	11974	7109	6937	11172	10900	450	2.30
10000	0.80	7339	0.8724	6402	10665	6926	6757	11024	10756	439	2.37
10000	0.80	6459	0.8909	5754	9386	6744	6580	10876	10611	428	2.45
10000	0.80	5635	0.9178	5172	8189	6575	6415	10738	10477	416	2.51
10000	0.80	4760	0.9682	4609	6918	6379	6224	10594	10337	404	2.59
10000	0.80	3838	1.0511	4034	5577	6152	6002	10422	10169	389	2.69
10000	0.80	2826	1.2169	3422	4108	5904	5760	10197	9949	372	2.81

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ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
10000	0.00	4.17	1.61	7.13	1.87	17.01	2.51	1.72	1.21	1.89	2.93	1.69
10000	0.00	4.14	1.59	7.03	1.85	16.67	2.47	1.70	1.21	1.86	2.87	1.67
10000	0.00	4.04	1.57	6.81	1.81	16.01	2.42	1.67	1.20	1.80	2.79	1.63
10000	0.00	3.83	1.53	6.43	1.77	15.08	2.36	1.64	1.19	1.73	2.71	1.59
10000	0.00	3.52	1.48	5.89	1.71	13.81	2.28	1.58	1.17	1.64	2.62	1.52
10000	0.00	3.24	1.44	5.39	1.66	12.60	2.21	1.52	1.15	1.55	2.53	1.46
10000	0.00	2.90	1.40	4.81	1.61	11.26	2.14	1.45	1.14	1.46	2.45	1.39
10000	0.00	2.59	1.35	4.25	1.55	9.94	2.06	1.38	1.12	1.36	2.36	1.32
10000	0.00	2.30	1.30	3.74	1.49	8.66	1.97	1.31	1.10	1.28	2.25	1.26
10000	0.00	1.99	1.24	3.18	1.42	7.28	1.86	1.24	1.08	1.21	2.15	1.20
10000	0.20	4.17	1.61	7.10	1.86	16.88	2.50	1.71	1.21	1.87	2.91	1.68
10000	0.20	4.14	1.59	7.01	1.84	16.57	2.46	1.69	1.20	1.84	2.85	1.66
10000	0.20	4.03	1.56	6.77	1.81	15.89	2.41	1.66	1.19	1.78	2.77	1.62
10000	0.20	3.80	1.52	6.36	1.76	14.91	2.34	1.62	1.18	1.71	2.68	1.57
10000	0.20	3.51	1.48	5.85	1.71	13.70	2.27	1.56	1.17	1.62	2.59	1.51
10000	0.20	3.22	1.44	5.33	1.66	12.47	2.20	1.50	1.15	1.53	2.50	1.44
10000	0.20	2.90	1.40	4.79	1.61	11.20	2.13	1.44	1.14	1.44	2.42	1.38
10000	0.20	2.59	1.35	4.24	1.55	9.89	2.05	1.37	1.12	1.35	2.33	1.31
10000	0.20	2.33	1.31	3.77	1.50	8.70	1.97	1.31	1.10	1.27	2.24	1.25
10000	0.40	4.16	1.60	7.02	1.85	16.55	2.47	1.68	1.20	1.83	2.84	1.64
10000	0.40	4.09	1.58	6.89	1.83	16.17	2.43	1.66	1.20	1.80	2.79	1.62
10000	0.40	3.96	1.55	6.60	1.79	15.45	2.37	1.63	1.19	1.73	2.70	1.58
10000	0.40	3.76	1.51	6.23	1.75	14.52	2.31	1.59	1.17	1.65	2.62	1.53
10000	0.40	3.50	1.48	5.77	1.70	13.41	2.25	1.53	1.16	1.57	2.54	1.47
10000	0.40	3.25	1.44	5.34	1.66	12.35	2.19	1.48	1.15	1.49	2.46	1.41
10000	0.40	2.99	1.41	4.88	1.62	11.24	2.13	1.42	1.13	1.41	2.38	1.35
10000	0.40	2.70	1.37	4.38	1.57	10.06	2.06	1.36	1.11	1.32	2.29	1.28
10000	0.40	2.45	1.33	3.91	1.52	8.91	1.98	1.30	1.10	1.24	2.19	1.22
10000	0.60	4.04	1.57	6.76	1.81	15.84	2.40	1.64	1.19	1.76	2.74	1.59
10000	0.60	3.99	1.56	6.63	1.79	15.46	2.37	1.62	1.18	1.72	2.69	1.57
10000	0.60	3.84	1.53	6.35	1.76	14.71	2.32	1.58	1.17	1.65	2.63	1.52
10000	0.60	3.65	1.50	6.00	1.72	13.86	2.27	1.54	1.16	1.58	2.55	1.47
10000	0.60	3.44	1.47	5.63	1.68	12.97	2.22	1.49	1.15	1.51	2.47	1.41
10000	0.60	3.26	1.44	5.29	1.65	12.10	2.17	1.44	1.14	1.44	2.39	1.36
10000	0.60	3.08	1.42	4.96	1.62	11.26	2.12	1.39	1.13	1.37	2.30	1.31
10000	0.60	2.79	1.38	4.45	1.57	10.06	2.05	1.33	1.11	1.28	2.22	1.24
10000	0.60	2.55	1.34	4.02	1.53	8.95	1.98	1.27	1.09	1.19	2.11	1.18
10000	0.80	3.85	1.53	6.35	1.76	14.68	2.31	1.58	1.17	1.65	2.62	1.52
10000	0.80	3.78	1.52	6.23	1.74	14.39	2.29	1.56	1.17	1.62	2.59	1.50
10000	0.80	3.61	1.49	5.91	1.71	13.61	2.25	1.51	1.16	1.55	2.51	1.44
10000	0.80	3.43	1.46	5.57	1.68	12.75	2.20	1.47	1.15	1.48	2.43	1.39
10000	0.80	3.26	1.44	5.25	1.65	11.94	2.15	1.42	1.13	1.41	2.35	1.34
10000	0.80	3.12	1.42	4.97	1.62	11.22	2.11	1.37	1.12	1.34	2.28	1.29
10000	0.80	2.95	1.40	4.67	1.59	10.45	2.07	1.33	1.11	1.27	2.20	1.24
10000	0.80	2.76	1.37	4.33	1.56	9.61	2.02	1.28	1.10	1.21	2.13	1.18
10000	0.80	2.57	1.35	3.99	1.52	8.71	1.96	1.22	1.09	1.13	2.04	1.12

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NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
15000	0.00	10994	0.5052	5553	19462	7494	7913	11326	11960	490	2.06
15000	0.00	10635	0.4959	5274	18827	7389	7802	11200	11826	485	2.06
15000	0.00	10223	0.4828	4935	18098	7259	7665	11035	11652	480	2.07
15000	0.00	9695	0.4711	4567	17162	7059	7453	10858	11466	471	2.10
15000	0.00	9015	0.4606	4152	15959	6802	7183	10679	11276	458	2.15
15000	0.00	8123	0.4510	3664	14380	6511	6875	10515	11103	439	2.23
15000	0.00	7168	0.4422	3170	12690	6209	6556	10355	10934	415	2.32
15000	0.00	6058	0.4360	2641	10725	5826	6152	10162	10730	384	2.42
15000	0.00	4845	0.4350	2107	8577	5383	5684	9918	10473	346	2.48
15000	0.00	3662	0.4454	1631	6482	4865	5138	9542	10075	303	2.53
15000	0.20	9494	0.5947	5646	16806	7490	7878	11331	11917	489	2.06
15000	0.20	9158	0.5867	5372	16211	7403	7786	11209	11789	485	2.07
15000	0.20	8745	0.5746	5025	15481	7276	7652	11046	11617	480	2.08
15000	0.20	8225	0.5650	4647	14561	7069	7435	10669	11431	471	2.12
15000	0.20	7559	0.5567	4206	13381	6805	7157	10693	11246	458	2.17
15000	0.20	6727	0.5515	3710	11909	6525	6863	10536	11081	439	2.25
15000	0.20	5848	0.5492	3212	10353	6226	6548	10376	10913	417	2.34
15000	0.20	4834	0.5540	2678	8558	5848	6150	10185	10712	387	2.45
15000	0.20	3854	0.5651	2178	6823	5452	5735	9931	10445	354	2.53
15000	0.40	8695	0.6819	5929	15392	7520	7816	11343	11790	487	2.08
15000	0.40	8392	0.6756	5669	14855	7440	7733	11235	11678	484	2.09
15000	0.40	7935	0.6666	5289	14046	7286	7574	11070	11506	478	2.11
15000	0.40	7380	0.6578	4855	13065	7070	7348	10906	11336	470	2.15
15000	0.40	6674	0.6593	4400	11815	6828	7098	10730	11153	457	2.22
15000	0.40	5862	0.6613	3877	10378	6558	6816	10577	10994	440	2.30
15000	0.40	5125	0.6675	3421	9073	6314	6563	10412	10823	423	2.39
15000	0.40	4143	0.6919	2867	7335	5951	6186	10225	10628	395	2.50
15000	0.40	3311	0.7189	2380	5861	5625	5847	9976	10369	370	2.60
15000	0.60	8472	0.7599	6438	14998	7541	7691	11368	11594	483	2.10
15000	0.60	8177	0.7536	6162	14475	7446	7594	11272	11496	480	2.12
15000	0.60	7593	0.7489	5686	13441	7251	7395	11113	11333	473	2.16
15000	0.60	7014	0.7505	5263	12416	7048	7188	10931	11148	464	2.21
15000	0.60	6270	0.7582	4754	11100	6836	6972	10772	10986	452	2.28
15000	0.60	5515	0.7687	4239	9763	6625	6757	10630	10841	439	2.36
15000	0.60	4815	0.7881	3795	8524	6438	6566	10468	10676	426	2.43
15000	0.60	3955	0.8247	3261	7001	6172	6294	10289	10493	407	2.53
15000	0.60	2968	0.8929	2650	5255	5820	5936	10053	10253	382	2.66
15000	0.80	8504	0.8365	7114	15053	7474	7430	11402	11337	474	2.16
15000	0.80	8263	0.8343	6894	14627	7388	7345	11294	11229	471	2.17
15000	0.80	7554	0.8357	6313	13372	7174	7133	11135	11071	461	2.23
15000	0.80	6801	0.8430	5733	12040	6992	6952	10992	10929	451	2.30
15000	0.80	6070	0.8526	5177	10745	6812	6773	10837	10774	440	2.37
15000	0.80	5325	0.8708	4637	9426	6629	6591	10694	10632	429	2.44
15000	0.80	4612	0.8989	4146	8165	6454	6416	10549	10485	417	2.51
15000	0.80	3685	0.9704	3575	6523	6194	6158	10371	10311	400	2.62
15000	0.80	2727	1.0942	2984	4827	5926	5892	10138	10080	381	2.74

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NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
15000	0.00	4.21	1.63	7.27	1.91	17.59	2.57	1.76	1.23	1.94	3.04	1.73
15000	0.00	4.18	1.62	7.17	1.88	17.19	2.53	1.73	1.22	1.90	2.96	1.70
15000	0.00	4.13	1.59	7.03	1.85	16.68	2.48	1.70	1.21	1.86	2.87	1.67
15000	0.00	4.03	1.57	6.80	1.81	15.98	2.42	1.67	1.20	1.80	2.78	1.63
15000	0.00	3.81	1.53	6.40	1.77	15.00	2.36	1.63	1.18	1.72	2.70	1.58
15000	0.00	3.51	1.48	5.86	1.71	13.73	2.28	1.57	1.17	1.63	2.61	1.52
15000	0.00	3.19	1.44	5.30	1.66	12.41	2.21	1.51	1.15	1.53	2.51	1.45
15000	0.00	2.81	1.38	4.64	1.59	10.85	2.12	1.43	1.13	1.43	2.42	1.37
15000	0.00	2.43	1.32	3.97	1.52	9.26	2.01	1.34	1.11	1.32	2.30	1.29
15000	0.00	2.07	1.26	3.34	1.44	7.68	1.90	1.26	1.09	1.23	2.18	1.21
15000	0.20	4.21	1.63	7.25	1.90	17.47	2.56	1.75	1.22	1.92	3.02	1.72
15000	0.20	4.18	1.62	7.15	1.88	17.09	2.52	1.72	1.21	1.89	2.94	1.69
15000	0.20	4.13	1.59	7.01	1.85	16.58	2.47	1.69	1.20	1.84	2.85	1.66
15000	0.20	4.02	1.56	6.76	1.81	15.86	2.42	1.66	1.19	1.78	2.76	1.62
15000	0.20	3.79	1.52	6.34	1.76	14.85	2.34	1.62	1.18	1.70	2.67	1.57
15000	0.20	3.49	1.48	5.82	1.71	13.62	2.27	1.56	1.17	1.61	2.58	1.50
15000	0.20	3.18	1.43	5.27	1.65	12.31	2.20	1.50	1.15	1.52	2.49	1.43
15000	0.20	2.80	1.38	4.62	1.59	10.79	2.11	1.42	1.13	1.41	2.39	1.35
15000	0.20	2.48	1.33	4.03	1.53	9.34	2.02	1.34	1.11	1.31	2.28	1.28
15000	0.40	4.21	1.62	7.18	1.89	17.12	2.53	1.71	1.21	1.88	2.94	1.68
15000	0.40	4.18	1.61	7.09	1.87	16.78	2.50	1.69	1.21	1.85	2.88	1.65
15000	0.40	4.10	1.58	6.90	1.83	16.21	2.44	1.66	1.20	1.79	2.79	1.62
15000	0.40	3.95	1.55	6.60	1.79	15.45	2.38	1.63	1.19	1.73	2.69	1.58
15000	0.40	3.74	1.51	6.20	1.74	14.46	2.31	1.58	1.17	1.65	2.62	1.52
15000	0.40	3.45	1.47	5.70	1.69	13.27	2.24	1.52	1.16	1.56	2.52	1.46
15000	0.40	3.21	1.44	5.27	1.65	12.19	2.18	1.47	1.14	1.48	2.44	1.40
15000	0.40	2.85	1.39	4.66	1.60	10.75	2.10	1.39	1.13	1.37	2.34	1.32
15000	0.40	2.58	1.35	4.17	1.55	9.53	2.03	1.33	1.11	1.28	2.24	1.25
15000	0.60	4.17	1.60	7.04	1.85	16.56	2.47	1.67	1.20	1.82	2.84	1.63
15000	0.60	4.12	1.59	6.91	1.83	16.21	2.44	1.65	1.20	1.79	2.78	1.61
15000	0.60	3.99	1.56	6.64	1.80	15.49	2.38	1.62	1.18	1.72	2.69	1.57
15000	0.60	3.84	1.53	6.36	1.76	14.72	2.33	1.58	1.17	1.65	2.63	1.52
15000	0.60	3.64	1.50	5.98	1.72	13.80	2.27	1.53	1.16	1.57	2.54	1.46
15000	0.60	3.42	1.46	5.59	1.68	12.87	2.22	1.48	1.15	1.50	2.46	1.41
15000	0.60	3.23	1.44	5.25	1.65	12.00	2.17	1.43	1.14	1.42	2.37	1.35
15000	0.60	2.99	1.41	4.80	1.61	10.89	2.10	1.37	1.12	1.34	2.27	1.29
15000	0.60	2.68	1.36	4.24	1.55	9.54	2.02	1.30	1.10	1.23	2.16	1.21
15000	0.80	4.01	1.56	6.68	1.80	15.58	2.38	1.62	1.19	1.73	2.71	1.57
15000	0.80	3.98	1.55	6.60	1.79	15.30	2.36	1.61	1.18	1.70	2.67	1.55
15000	0.80	3.80	1.52	6.27	1.75	14.48	2.30	1.57	1.17	1.63	2.60	1.50
15000	0.80	3.62	1.49	5.94	1.71	13.69	2.26	1.52	1.16	1.56	2.52	1.45
15000	0.80	3.44	1.47	5.60	1.68	12.83	2.21	1.47	1.15	1.48	2.44	1.39
15000	0.80	3.27	1.44	5.27	1.65	11.99	2.16	1.42	1.13	1.41	2.36	1.34
15000	0.80	3.12	1.42	4.98	1.62	11.23	2.11	1.37	1.12	1.34	2.27	1.29
15000	0.80	2.89	1.39	4.57	1.58	10.22	2.06	1.31	1.11	1.26	2.19	1.22
15000	0.80	2.67	1.36	4.17	1.55	9.18	2.00	1.25	1.09	1.17	2.08	1.15

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ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
20000	0.65	7315	0.7710	5640	15895	7537	7793	11338	11723	487	2.09
20000	0.65	7084	0.7652	5421	15395	7464	7718	11248	11630	484	2.10
20000	0.65	6647	0.7569	5031	14444	7306	7554	11089	11465	479	2.13
20000	0.65	6194	0.7522	4659	13461	7112	7354	10918	11289	472	2.17
20000	0.65	5640	0.7553	4260	12256	6895	7130	10740	11105	461	2.23
20000	0.65	5017	0.7638	3831	10901	6695	6923	10588	10948	449	2.30
20000	0.65	4396	0.7784	3421	9552	6503	6724	10433	10788	437	2.38
20000	0.65	3677	0.8078	2970	7990	6262	6474	10245	10593	420	2.47
20000	0.65	2743	0.8760	2469	5962	5903	6104	10012	10352	395	2.62
20000	0.70	7342	0.7869	5777	15954	7533	7741	11341	11654	485	2.10
20000	0.70	7133	0.7821	5579	15501	7470	7676	11259	11570	483	2.11
20000	0.70	6628	0.7755	5140	14403	7283	7484	11103	11410	476	2.15
20000	0.70	6235	0.7738	4824	13548	7120	7317	10918	11220	470	2.18
20000	0.70	5613	0.7780	4367	12198	6892	7082	10755	11052	459	2.25
20000	0.70	4998	0.7858	3927	10860	6701	6886	10607	10900	447	2.32
20000	0.70	4363	0.8019	3499	9482	6502	6681	10450	10738	435	2.40
20000	0.70	3635	0.8366	3041	7899	6273	6446	10266	10550	418	2.49
20000	0.70	2704	0.9176	2481	5876	5935	6099	10033	10310	396	2.63
20000	0.75	7378	0.8046	5936	16032	7532	7690	11347	11584	483	2.11
20000	0.75	7169	0.7997	5733	15578	7461	7617	11271	11507	481	2.12
20000	0.75	6665	0.7948	5297	14483	7266	7418	11109	11340	474	2.16
20000	0.75	6158	0.7948	4894	13382	7066	7214	10937	11165	465	2.21
20000	0.75	5567	0.8009	4459	12097	6871	7014	10773	10998	455	2.27
20000	0.75	4974	0.8096	4027	10809	6700	6840	10624	10846	444	2.34
20000	0.75	4331	0.8255	3575	9411	6495	6631	10469	10687	431	2.42
20000	0.75	3606	0.8648	3118	7836	6284	6415	10290	10504	416	2.50
20000	0.75	2680	0.9531	2554	5825	5954	6078	10052	10262	395	2.65
20000	0.80	7395	0.8270	6116	16069	7529	7634	11359	11516	481	2.12
20000	0.80	7148	0.8211	5869	15534	7430	7533	11286	11442	478	2.14
20000	0.80	6727	0.8152	5463	14618	7256	7356	11115	11269	472	2.17
20000	0.80	6182	0.8165	5047	13434	7052	7150	10943	11094	462	2.23
20000	0.80	5546	0.8232	4566	12053	6863	6958	10795	10944	452	2.29
20000	0.80	4926	0.8337	4107	10705	6682	6774	10643	10790	441	2.37
20000	0.80	4284	0.8535	3657	9310	6491	6581	10490	10635	428	2.45
20000	0.80	3586	0.8910	3195	7792	6288	6375	10314	10456	414	2.52
20000	0.80	2612	1.0091	2617	5676	5949	6031	10073	10212	391	2.67
20000	0.85	7402	0.8485	6280	16084	7504	7553	11378	11452	479	2.13
20000	0.85	7131	0.8467	6037	15495	7407	7455	11297	11370	475	2.15
20000	0.85	6730	0.8435	5677	14625	7241	7288	11116	11188	469	2.19
20000	0.85	6169	0.8397	5180	13406	7038	7084	10962	11033	459	2.25
20000	0.85	5554	0.8452	4694	12070	6862	6907	10811	10881	448	2.31
20000	0.85	4894	0.8585	4201	10634	6671	6714	10663	10733	437	2.39
20000	0.85	4246	0.8621	3746	9228	6484	6526	10512	10580	425	2.47
20000	0.85	3540	0.9226	3266	7692	6276	6316	10337	10404	410	2.55
20000	0.85	2578	1.0430	2689	5604	5954	5993	10095	10161	388	2.69

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STANDARD DAY TAMB

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
20000	0.65	4.21	1.62	7.16	1.88	16.93	2.51	1.69	1.21	1.85	2.91	1.66
20000	0.65	4.18	1.61	7.07	1.86	16.65	2.48	1.68	1.20	1.82	2.85	1.64
20000	0.65	4.08	1.58	6.84	1.83	16.03	2.43	1.64	1.19	1.77	2.76	1.60
20000	0.65	3.97	1.55	6.60	1.79	15.35	2.37	1.61	1.18	1.70	2.67	1.56
20000	0.65	3.79	1.52	6.26	1.75	14.47	2.31	1.57	1.17	1.63	2.60	1.50
20000	0.65	3.59	1.49	5.89	1.71	13.56	2.26	1.51	1.16	1.55	2.51	1.44
20000	0.65	3.38	1.46	5.52	1.68	12.66	2.21	1.46	1.14	1.47	2.42	1.39
20000	0.65	3.16	1.43	5.08	1.64	11.56	2.14	1.40	1.13	1.38	2.32	1.32
20000	0.65	2.82	1.38	4.49	1.58	10.11	2.06	1.32	1.11	1.27	2.20	1.23
20000	0.70	4.19	1.61	7.09	1.87	16.73	2.49	1.68	1.20	1.83	2.87	1.64
20000	0.70	4.16	1.60	7.01	1.85	16.48	2.47	1.67	1.20	1.81	2.82	1.62
20000	0.70	4.03	1.57	6.73	1.81	15.77	2.41	1.63	1.19	1.74	2.72	1.58
20000	0.70	3.96	1.55	6.56	1.78	15.19	2.36	1.60	1.18	1.69	2.66	1.54
20000	0.70	3.75	1.51	6.18	1.74	14.26	2.30	1.55	1.17	1.61	2.57	1.49
20000	0.70	3.55	1.48	5.82	1.70	13.38	2.25	1.50	1.15	1.53	2.49	1.43
20000	0.70	3.35	1.45	5.44	1.67	12.44	2.19	1.45	1.14	1.45	2.40	1.37
20000	0.70	3.13	1.43	5.03	1.63	11.40	2.13	1.39	1.13	1.36	2.30	1.30
20000	0.70	2.83	1.38	4.48	1.58	10.04	2.05	1.31	1.11	1.25	2.17	1.22
20000	0.75	4.17	1.60	7.03	1.85	16.53	2.47	1.67	1.20	1.81	2.83	1.63
20000	0.75	4.13	1.59	6.93	1.84	16.25	2.44	1.65	1.20	1.79	2.78	1.61
20000	0.75	4.00	1.56	6.66	1.80	15.54	2.39	1.62	1.18	1.72	2.70	1.57
20000	0.75	3.87	1.53	6.40	1.77	14.81	2.34	1.58	1.17	1.65	2.62	1.52
20000	0.75	3.68	1.50	6.06	1.73	13.97	2.28	1.54	1.16	1.58	2.55	1.47
20000	0.75	3.51	1.48	5.73	1.70	13.15	2.23	1.49	1.15	1.51	2.46	1.41
20000	0.75	3.30	1.45	5.35	1.66	12.20	2.18	1.43	1.14	1.43	2.37	1.35
20000	0.75	3.11	1.42	4.96	1.62	11.24	2.12	1.37	1.12	1.34	2.27	1.29
20000	0.75	2.82	1.38	4.45	1.57	9.91	2.04	1.30	1.10	1.23	2.15	1.20
20000	0.80	4.14	1.59	6.96	1.84	16.31	2.45	1.66	1.20	1.79	2.79	1.61
20000	0.80	4.07	1.58	6.80	1.82	15.94	2.42	1.64	1.19	1.76	2.75	1.59
20000	0.80	3.98	1.55	6.61	1.79	15.35	2.37	1.61	1.18	1.70	2.67	1.55
20000	0.80	3.82	1.52	6.30	1.75	14.55	2.31	1.57	1.17	1.63	2.60	1.50
20000	0.80	3.63	1.49	5.95	1.72	13.72	2.26	1.52	1.16	1.56	2.52	1.45
20000	0.80	3.44	1.47	5.61	1.68	12.84	2.21	1.47	1.15	1.48	2.44	1.39
20000	0.80	3.26	1.44	5.25	1.65	11.95	2.16	1.42	1.13	1.40	2.35	1.33
20000	0.80	3.08	1.42	4.90	1.62	11.04	2.11	1.36	1.12	1.32	2.25	1.27
20000	0.80	2.78	1.38	4.38	1.57	9.73	2.03	1.28	1.10	1.21	2.14	1.18
20000	0.85	4.08	1.58	6.83	1.82	16.01	2.42	1.64	1.19	1.77	2.75	1.60
20000	0.85	4.02	1.57	6.70	1.81	15.66	2.39	1.62	1.19	1.73	2.71	1.57
20000	0.85	3.94	1.54	6.52	1.78	15.08	2.35	1.59	1.18	1.68	2.65	1.54
20000	0.85	3.75	1.51	6.18	1.74	14.27	2.29	1.55	1.17	1.60	2.57	1.48
20000	0.85	3.58	1.49	5.85	1.71	13.45	2.25	1.50	1.15	1.53	2.49	1.43
20000	0.85	3.39	1.46	5.49	1.67	12.55	2.19	1.45	1.14	1.46	2.41	1.37
20000	0.85	3.21	1.44	5.16	1.64	11.69	2.14	1.40	1.13	1.38	2.32	1.32
20000	0.85	3.03	1.41	4.81	1.61	10.79	2.09	1.34	1.12	1.30	2.22	1.25
20000	0.85	2.75	1.37	4.32	1.56	9.55	2.02	1.26	1.10	1.19	2.11	1.17

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STANDARD DAY TAMB

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
25000	0.65	6295	0.7641	4810	16931	7588	8007	11321	11946	492	2.09
25000	0.65	6040	0.7579	4578	16246	7445	7857	11211	11830	488	2.09
25000	0.65	5704	0.7496	4276	15343	7325	7730	11049	11659	483	2.11
25000	0.65	5348	0.7405	3960	14386	7160	7564	10882	11483	478	2.14
25000	0.65	4950	0.7360	3643	13315	6962	7347	10712	11304	471	2.17
25000	0.65	4481	0.7395	3314	12054	6741	7113	10540	11122	459	2.24
25000	0.65	3970	0.7501	2978	10679	6547	6908	10375	10947	447	2.31
25000	0.65	3389	0.7686	2605	9116	6321	6670	10187	10749	433	2.40
25000	0.65	2612	0.8205	2143	7027	6001	6332	9948	10498	409	2.52
25000	0.70	6354	0.7810	4962	17090	7562	7930	11340	11893	490	2.09
25000	0.70	6094	0.7743	4718	16391	7455	7818	11223	11770	487	2.09
25000	0.70	5759	0.7654	4408	15489	7333	7690	11062	11600	482	2.11
25000	0.70	5341	0.7590	4054	14366	7147	7495	10898	11428	476	2.15
25000	0.70	4978	0.7577	3772	13390	6964	7303	10714	11236	469	2.18
25000	0.70	4479	0.7614	3411	12049	6742	7070	10549	11063	457	2.25
25000	0.70	3964	0.7705	3054	10663	6552	6871	10395	10901	445	2.32
25000	0.70	3356	0.7929	2661	9027	6317	6624	10204	10701	430	2.42
25000	0.70	2578	0.8501	2191	6935	6006	6299	9969	10455	408	2.55
25000	0.75	6367	0.8004	5096	17127	7541	7856	11344	11819	489	2.09
25000	0.75	6146	0.7923	4870	16533	7462	7774	11235	11705	486	2.10
25000	0.75	5821	0.7820	4552	15656	7339	7646	11074	11537	482	2.12
25000	0.75	5366	0.7762	4165	14432	7130	7429	10913	11370	474	2.16
25000	0.75	4965	0.7772	3859	13355	6931	7221	10727	11176	465	2.21
25000	0.75	4456	0.7834	3490	11985	6726	7007	10567	11009	455	2.28
25000	0.75	3946	0.7931	3130	10615	6547	6821	10413	10849	443	2.35
25000	0.75	3337	0.8155	2721	8977	6314	6578	10224	10652	428	2.45
25000	0.75	2547	0.8819	2246	6851	6016	6268	9991	10410	407	2.57
25000	0.80	6377	0.8217	5239	17152	7539	7800	11336	11731	487	2.09
25000	0.80	6167	0.8161	5033	16589	7468	7726	11248	11638	484	2.10
25000	0.80	5820	0.8032	4675	15655	7315	7568	11088	11473	479	2.13
25000	0.80	5442	0.7958	4331	14638	7126	7373	10917	11295	472	2.17
25000	0.80	4986	0.7967	3973	13413	6916	7156	10739	11112	463	2.23
25000	0.80	4455	0.8045	3583	11982	6725	6958	10590	10957	452	2.29
25000	0.80	3933	0.8161	3209	10579	6538	6765	10430	10792	440	2.37
25000	0.80	3315	0.8418	2790	8916	6312	6531	10245	10600	425	2.47
25000	0.80	2502	0.9160	2292	6730	5996	6204	10012	10359	403	2.60
25000	0.85	6440	0.8369	5389	17322	7534	7739	11341	11649	485	2.10
25000	0.85	6252	0.8327	5206	16816	7472	7675	11260	11566	483	2.11
25000	0.85	5797	0.8268	4793	15593	7286	7484	11106	11408	476	2.15
25000	0.85	5469	0.8233	4502	14710	7123	7317	10920	11217	470	2.18
25000	0.85	4975	0.8202	4080	13381	6901	7089	10758	11051	459	2.25
25000	0.85	4457	0.8260	3681	11988	6723	6906	10612	10901	448	2.31
25000	0.85	3903	0.8405	3280	10497	6526	6703	10452	10736	436	2.40
25000	0.85	3282	0.8765	2857	8828	6307	6478	10269	10548	421	2.49
25000	0.85	2457	0.9530	2341	6608	5978	6141	10034	10307	399	2.63

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ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
25000	0.65	4.23	1.64	7.28	1.92	17.50	2.58	1.73	1.22	1.91	3.03	1.70
25000	0.65	4.21	1.63	7.20	1.90	17.15	2.55	1.71	1.21	1.87	2.96	1.67
25000	0.65	4.17	1.61	7.05	1.87	16.64	2.50	1.67	1.20	1.82	2.86	1.63
25000	0.65	4.08	1.58	6.84	1.83	16.02	2.44	1.64	1.19	1.76	2.76	1.59
25000	0.65	3.94	1.55	6.56	1.79	15.29	2.38	1.60	1.18	1.70	2.67	1.55
25000	0.65	3.75	1.52	6.21	1.75	14.38	2.32	1.56	1.17	1.62	2.59	1.49
25000	0.65	3.56	1.48	5.84	1.71	13.46	2.26	1.50	1.16	1.54	2.50	1.43
25000	0.65	3.33	1.45	5.41	1.67	12.39	2.20	1.45	1.14	1.45	2.40	1.37
25000	0.65	3.02	1.41	4.84	1.61	10.96	2.11	1.36	1.12	1.33	2.26	1.28
25000	0.70	4.23	1.64	7.26	1.91	17.37	2.56	1.72	1.22	1.90	3.00	1.69
25000	0.70	4.21	1.63	7.17	1.89	17.01	2.53	1.70	1.21	1.86	2.92	1.66
25000	0.70	4.16	1.60	7.01	1.86	16.49	2.48	1.66	1.20	1.81	2.83	1.62
25000	0.70	4.03	1.57	6.74	1.82	15.78	2.42	1.63	1.19	1.74	2.73	1.58
25000	0.70	3.93	1.55	6.52	1.78	15.12	2.37	1.59	1.18	1.68	2.65	1.54
25000	0.70	3.72	1.51	6.14	1.74	14.17	2.30	1.55	1.17	1.60	2.57	1.48
25000	0.70	3.53	1.48	5.78	1.70	13.29	2.25	1.49	1.15	1.52	2.48	1.42
25000	0.70	3.29	1.45	5.33	1.66	12.17	2.18	1.43	1.14	1.42	2.37	1.35
25000	0.70	3.00	1.41	4.78	1.61	10.79	2.10	1.35	1.12	1.31	2.24	1.26
25000	0.75	4.23	1.63	7.22	1.90	17.18	2.54	1.71	1.21	1.88	2.96	1.67
25000	0.75	4.20	1.62	7.12	1.88	16.84	2.51	1.69	1.21	1.84	2.89	1.65
25000	0.75	4.14	1.59	6.97	1.84	16.34	2.46	1.66	1.20	1.79	2.79	1.61
25000	0.75	3.99	1.56	6.65	1.80	15.55	2.39	1.62	1.18	1.72	2.69	1.56
25000	0.75	3.87	1.53	6.40	1.77	14.82	2.34	1.58	1.17	1.65	2.63	1.52
25000	0.75	3.67	1.50	6.03	1.73	13.92	2.28	1.53	1.16	1.57	2.54	1.46
25000	0.75	3.48	1.47	5.69	1.69	13.06	2.23	1.48	1.15	1.50	2.45	1.40
25000	0.75	3.25	1.44	5.25	1.65	11.95	2.17	1.42	1.13	1.40	2.35	1.34
25000	0.75	2.97	1.40	4.73	1.60	10.63	2.09	1.34	1.12	1.29	2.21	1.25
25000	0.80	4.22	1.62	7.17	1.88	16.96	2.52	1.69	1.21	1.85	2.91	1.66
25000	0.80	4.18	1.61	7.07	1.86	16.67	2.49	1.68	1.20	1.82	2.85	1.64
25000	0.80	4.09	1.58	6.86	1.83	16.06	2.43	1.64	1.19	1.77	2.76	1.60
25000	0.80	3.98	1.56	6.62	1.79	15.39	2.38	1.61	1.18	1.71	2.67	1.55
25000	0.80	3.82	1.52	6.30	1.75	14.56	2.32	1.57	1.17	1.63	2.60	1.50
25000	0.80	3.62	1.49	5.95	1.72	13.70	2.27	1.52	1.16	1.55	2.51	1.45
25000	0.80	3.43	1.47	5.59	1.68	12.80	2.21	1.46	1.15	1.48	2.43	1.39
25000	0.80	3.21	1.44	5.17	1.64	11.73	2.15	1.40	1.13	1.38	2.32	1.32
25000	0.80	2.92	1.40	4.63	1.59	10.39	2.07	1.32	1.11	1.27	2.19	1.23
25000	0.85	4.19	1.61	7.09	1.87	16.72	2.49	1.68	1.20	1.83	2.87	1.64
25000	0.85	4.16	1.60	7.01	1.85	16.47	2.46	1.66	1.20	1.81	2.82	1.62
25000	0.85	4.03	1.57	6.73	1.81	15.75	2.41	1.63	1.19	1.74	2.72	1.58
25000	0.85	3.96	1.55	6.56	1.78	15.19	2.36	1.60	1.18	1.69	2.65	1.54
25000	0.85	3.75	1.51	6.19	1.74	14.28	2.30	1.55	1.17	1.60	2.57	1.48
25000	0.85	3.57	1.49	5.85	1.71	13.45	2.25	1.50	1.15	1.53	2.49	1.43
25000	0.85	3.37	1.46	5.47	1.67	12.50	2.20	1.45	1.14	1.45	2.40	1.37
25000	0.85	3.17	1.43	5.07	1.63	11.48	2.14	1.38	1.13	1.36	2.30	1.30
25000	0.85	2.87	1.39	4.54	1.58	10.14	2.06	1.30	1.11	1.24	2.17	1.21

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NO BLEED OR POWER EXTRACTION
STANDARD DAY TAMB

ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
30000	0.65	5239	0.7563	3962	17600	7616	8209	11242	12117	494	2.09
30000	0.65	5061	0.7513	3802	17001	7493	8076	11150	12017	491	2.09
30000	0.65	4782	0.7425	3550	16066	7293	7860	10998	11854	486	2.10
30000	0.65	4508	0.7341	3309	15144	7169	7727	10832	11675	481	2.11
30000	0.65	4213	0.7269	3062	14153	7005	7550	10662	11492	476	2.14
30000	0.65	3857	0.7223	2786	12959	6781	7309	10495	11312	467	2.19
30000	0.65	3455	0.7274	2513	11606	6551	7061	10296	11099	455	2.26
30000	0.65	2936	0.7453	2189	9870	6316	6808	10100	10886	439	2.35
30000	0.65	2295	0.7882	1809	7712	5994	6460	9844	10610	417	2.48
30000	0.70	5272	0.7734	4078	17713	7592	8133	11253	12054	492	2.09
30000	0.70	5117	0.7679	3929	17191	7477	8009	11171	11966	490	2.09
30000	0.70	4834	0.7589	3668	16239	7306	7826	11015	11799	485	2.10
30000	0.70	4555	0.7500	3416	15304	7180	7691	10847	11619	481	2.12
30000	0.70	4222	0.7444	3143	14185	6993	7490	10682	11442	474	2.15
30000	0.70	3876	0.7441	2884	13021	6779	7262	10502	11250	465	2.20
30000	0.70	3464	0.7484	2592	11637	6558	7025	10321	11056	453	2.27
30000	0.70	2974	0.7632	2269	9991	6338	6790	10131	10852	439	2.36
30000	0.70	2328	0.8065	1862	7821	6031	6460	9879	10582	417	2.48
30000	0.75	5293	0.7944	4205	17781	7563	8048	11266	11989	491	2.09
30000	0.75	5160	0.7880	4066	17335	7456	7934	11193	11912	489	2.09
30000	0.75	4887	0.7768	3796	16416	7316	7785	11033	11741	484	2.10
30000	0.75	4609	0.7664	3533	15486	7188	7649	10864	11562	480	2.12
30000	0.75	4241	0.7614	3229	14248	6977	7425	10701	11388	472	2.17
30000	0.75	3887	0.7637	2968	13058	6769	7203	10523	11198	463	2.22
30000	0.75	3485	0.7698	2683	11708	6572	6993	10347	11011	452	2.28
30000	0.75	3004	0.7829	2352	10091	6355	6763	10161	10813	438	2.37
30000	0.75	2356	0.8304	1957	7916	6063	6452	9916	10552	417	2.49
30000	0.80	5425	0.8141	4417	18227	7580	8011	11316	11960	491	2.09
30000	0.80	5198	0.8085	4203	17464	7442	7865	11211	11848	487	2.09
30000	0.80	4913	0.7998	3929	16505	7324	7740	11047	11675	483	2.11
30000	0.80	4629	0.7871	3643	15551	7172	7580	10878	11496	478	2.14
30000	0.80	4296	0.7801	3352	14434	6971	7367	10709	11318	470	2.17
30000	0.80	3918	0.7818	3063	13163	6759	7143	10536	11135	461	2.24
30000	0.80	3491	0.7908	2761	11729	6574	6948	10372	10962	449	2.30
30000	0.80	3001	0.8058	2418	10082	6356	6717	10184	10763	435	2.39
30000	0.80	2359	0.8524	2010	7924	6070	6415	9945	10510	415	2.51
30000	0.85	5531	0.8290	4565	18580	7561	7933	11340	11898	490	2.09
30000	0.85	5289	0.8240	4358	17769	7453	7820	11222	11774	486	2.10
30000	0.85	4989	0.8161	4072	16761	7331	7691	11061	11605	482	2.11
30000	0.85	4624	0.8098	3745	15536	7147	7499	10898	11434	475	2.15
30000	0.85	4323	0.8055	3482	14522	6962	7305	10715	11242	468	2.19
30000	0.85	3929	0.8035	3157	13200	6749	7081	10551	11070	457	2.25
30000	0.85	3509	0.8106	2844	11789	6577	6901	10393	10904	446	2.32
30000	0.85	2985	0.8297	2477	10028	6343	6655	10205	10707	432	2.42
30000	0.85	2344	0.8798	2062	7875	6073	6371	9970	10460	412	2.53

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STANDARD DAY TAMB

ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
30000	0.65	4.20	1.66	7.32	1.94	17.84	2.62	1.76	1.24	1.94	3.12	1.72
30000	0.65	4.20	1.65	7.26	1.93	17.54	2.60	1.73	1.23	1.91	3.06	1.70
30000	0.65	4.18	1.63	7.15	1.90	17.07	2.56	1.70	1.21	1.86	2.96	1.66
30000	0.65	4.13	1.61	7.01	1.87	16.54	2.50	1.66	1.20	1.81	2.86	1.62
30000	0.65	4.04	1.58	6.79	1.83	15.90	2.44	1.63	1.19	1.75	2.76	1.58
30000	0.65	3.86	1.55	6.46	1.79	15.09	2.38	1.59	1.18	1.67	2.65	1.53
30000	0.65	3.69	1.51	6.09	1.74	14.09	2.31	1.54	1.17	1.59	2.57	1.47
30000	0.65	3.44	1.47	5.63	1.69	12.95	2.24	1.47	1.15	1.49	2.46	1.40
30000	0.65	3.12	1.43	5.03	1.64	11.45	2.15	1.39	1.13	1.37	2.31	1.31
30000	0.70	4.21	1.65	7.29	1.93	17.68	2.61	1.74	1.23	1.92	3.09	1.71
30000	0.70	4.20	1.65	7.24	1.92	17.43	2.58	1.72	1.22	1.90	3.03	1.69
30000	0.70	4.18	1.63	7.13	1.89	16.94	2.54	1.69	1.21	1.85	2.93	1.65
30000	0.70	4.13	1.60	6.97	1.86	16.40	2.49	1.66	1.20	1.80	2.83	1.61
30000	0.70	4.01	1.57	6.71	1.82	15.70	2.42	1.62	1.19	1.73	2.73	1.57
30000	0.70	3.86	1.54	6.42	1.78	14.90	2.36	1.58	1.18	1.66	2.64	1.52
30000	0.70	3.66	1.51	6.03	1.73	13.93	2.30	1.53	1.16	1.57	2.55	1.46
30000	0.70	3.43	1.47	5.60	1.69	12.87	2.23	1.47	1.15	1.48	2.44	1.39
30000	0.70	3.13	1.43	5.04	1.64	11.42	2.15	1.38	1.13	1.36	2.30	1.30
30000	0.75	4.21	1.65	7.27	1.92	17.53	2.59	1.73	1.22	1.91	3.05	1.70
30000	0.75	4.21	1.64	7.22	1.91	17.30	2.57	1.71	1.22	1.88	3.00	1.68
30000	0.75	4.17	1.62	7.09	1.88	16.80	2.52	1.68	1.21	1.83	2.90	1.64
30000	0.75	4.11	1.60	6.93	1.85	16.26	2.47	1.65	1.20	1.78	2.80	1.61
30000	0.75	3.97	1.56	6.62	1.81	15.47	2.40	1.61	1.18	1.71	2.70	1.56
30000	0.75	3.82	1.53	6.33	1.77	14.68	2.35	1.57	1.17	1.64	2.62	1.51
30000	0.75	3.64	1.50	5.98	1.73	13.78	2.29	1.52	1.16	1.56	2.53	1.45
30000	0.75	3.41	1.47	5.56	1.69	12.74	2.22	1.46	1.14	1.47	2.43	1.38
30000	0.75	3.13	1.43	5.02	1.63	11.35	2.14	1.38	1.13	1.35	2.29	1.29
30000	0.80	4.22	1.65	7.26	1.92	17.48	2.58	1.73	1.22	1.91	3.04	1.70
30000	0.80	4.20	1.64	7.18	1.90	17.14	2.55	1.70	1.21	1.87	2.96	1.67
30000	0.80	4.16	1.61	7.05	1.87	16.63	2.50	1.67	1.20	1.82	2.87	1.63
30000	0.80	4.07	1.59	6.84	1.83	16.02	2.45	1.64	1.19	1.76	2.77	1.59
30000	0.80	3.95	1.56	6.56	1.80	15.30	2.38	1.60	1.18	1.69	2.67	1.55
30000	0.80	3.78	1.52	6.24	1.76	14.45	2.33	1.56	1.17	1.62	2.59	1.49
30000	0.80	3.60	1.49	5.90	1.72	13.58	2.27	1.50	1.16	1.54	2.51	1.43
30000	0.80	3.37	1.46	5.48	1.68	12.52	2.21	1.45	1.14	1.45	2.40	1.37
30000	0.80	3.10	1.42	4.95	1.63	11.18	2.13	1.36	1.12	1.33	2.26	1.28
30000	0.85	4.22	1.64	7.24	1.91	17.33	2.56	1.72	1.22	1.89	3.00	1.68
30000	0.85	4.20	1.63	7.15	1.89	16.96	2.53	1.69	1.21	1.85	2.93	1.65
30000	0.85	4.14	1.60	7.00	1.86	16.46	2.48	1.66	1.20	1.80	2.83	1.62
30000	0.85	4.02	1.57	6.73	1.82	15.75	2.42	1.62	1.19	1.74	2.73	1.57
30000	0.85	3.92	1.55	6.51	1.78	15.09	2.37	1.59	1.18	1.68	2.65	1.53
30000	0.85	3.73	1.51	6.14	1.74	14.19	2.31	1.54	1.17	1.59	2.57	1.48
30000	0.85	3.55	1.49	5.82	1.71	13.36	2.25	1.49	1.15	1.52	2.48	1.42
30000	0.85	3.32	1.45	5.37	1.67	12.24	2.19	1.43	1.14	1.42	2.37	1.35
30000	0.85	3.07	1.42	4.88	1.62	10.98	2.11	1.35	1.12	1.31	2.24	1.26

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ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
35000	0.65	4337	0.7512	3258	18378	7628	8406	11238	12384	496	2.12
35000	0.65	4123	0.7420	3059	17472	7444	8203	11084	12214	492	2.13
35000	0.65	3915	0.7336	2872	16591	7255	7994	10932	12046	488	2.14
35000	0.65	3697	0.7259	2683	15665	7097	7821	10772	11870	483	2.14
35000	0.65	3476	0.7180	2496	14729	6967	7677	10601	11682	478	2.16
35000	0.65	3197	0.7147	2285	13549	6751	7439	10410	11471	470	2.21
35000	0.65	2841	0.7166	2036	12039	6480	7141	10205	11245	458	2.28
35000	0.65	2382	0.7353	1751	10093	6221	6855	9993	11012	440	2.37
35000	0.65	1872	0.7771	1455	7934	5899	6501	9723	10715	418	2.50
35000	0.70	4371	0.7688	3360	18519	7616	8340	11233	12302	495	2.12
35000	0.70	4185	0.7596	3179	17734	7455	8164	11101	12157	491	2.12
35000	0.70	3971	0.7498	2978	16829	7258	7949	10950	11992	487	2.13
35000	0.70	3747	0.7418	2780	15878	7117	7795	10789	11815	482	2.14
35000	0.70	3521	0.7339	2584	14919	6984	7648	10619	11630	477	2.16
35000	0.70	3229	0.7323	2365	13685	6759	7403	10431	11423	469	2.21
35000	0.70	2855	0.7354	2099	12098	6494	7112	10235	11209	456	2.28
35000	0.70	2425	0.7509	1821	10274	6248	6842	10018	10972	440	2.37
35000	0.70	1913	0.7957	1522	8105	5950	6517	9754	10682	420	2.50
35000	0.75	4398	0.7898	3474	18637	7606	8275	11234	12223	494	2.11
35000	0.75	4231	0.7815	3306	17927	7461	8118	11121	12100	491	2.12
35000	0.75	4023	0.7688	3092	17045	7257	7895	10971	11936	486	2.12
35000	0.75	3862	0.7589	2885	16109	7135	7763	10806	11757	481	2.14
35000	0.75	3566	0.7503	2675	15110	6987	7602	10636	11572	476	2.16
35000	0.75	3273	0.7476	2447	13869	6765	7360	10456	11376	468	2.21
35000	0.75	2885	0.7545	2177	12227	6510	7083	10261	11164	455	2.28
35000	0.75	2472	0.7698	1903	10476	6282	6835	10046	10930	440	2.37
35000	0.75	1943	0.8130	1580	8236	5975	6500	9790	10651	419	2.50
35000	0.80	4472	0.8045	3597	18947	7598	8209	11242	12147	493	2.10
35000	0.80	4311	0.7993	3446	18268	7467	6068	11143	12040	490	2.11
35000	0.80	4067	0.7914	3219	17235	7276	7862	10990	11874	485	2.11
35000	0.80	3841	0.7809	2999	16276	7152	7727	10825	11696	481	2.13
35000	0.80	3604	0.7694	2773	15272	6983	7545	10654	11512	475	2.16
35000	0.80	3296	0.7652	2522	13965	6755	7299	10483	11326	466	2.21
35000	0.80	2926	0.7722	2260	12400	6522	7047	10290	11119	454	2.29
35000	0.80	2511	0.7889	1961	10640	6306	6814	10086	10898	439	2.38
35000	0.80	1987	0.8290	1647	8419	6006	6489	9828	10619	419	2.50
35000	0.85	4566	0.8160	3735	19348	7587	8138	11252	12070	492	2.09
35000	0.85	4421	0.8135	3596	18731	7470	8013	11167	11979	489	2.10
35000	0.85	4163	0.8068	3359	17640	7300	7831	11010	11810	484	2.11
35000	0.85	3912	0.7991	3125	16575	7171	7693	10843	11631	480	2.13
35000	0.85	3624	0.7943	2878	15354	6986	7494	10676	11452	473	2.16
35000	0.85	3335	0.7879	2627	14130	6764	7255	10499	11262	464	2.22
35000	0.85	2991	0.7903	2364	12675	6547	7023	10314	11064	453	2.29
35000	0.85	2558	0.8069	2064	10842	6326	6785	10124	10859	438	2.38
35000	0.85	2026	0.8491	1720	8584	6036	6475	9670	10588	418	2.50

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ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
35000	0.65	4.10	1.67	7.27	1.96	18.10	2.68	1.79	1.25	1.98	3.26	1.75
35000	0.65	4.07	1.65	7.16	1.94	17.60	2.64	1.75	1.24	1.93	3.16	1.72
35000	0.65	4.08	1.64	7.08	1.92	17.18	2.60	1.72	1.22	1.88	3.07	1.68
35000	0.65	4.05	1.62	6.96	1.89	16.69	2.55	1.69	1.21	1.83	2.96	1.64
35000	0.65	4.00	1.60	6.81	1.86	16.14	2.50	1.65	1.20	1.78	2.85	1.61
35000	0.65	3.88	1.57	6.54	1.82	15.36	2.43	1.61	1.19	1.71	2.75	1.56
35000	0.65	3.66	1.52	6.12	1.76	14.30	2.35	1.56	1.17	1.61	2.64	1.49
35000	0.65	3.40	1.48	5.61	1.71	13.01	2.26	1.48	1.15	1.50	2.50	1.41
35000	0.65	3.10	1.44	5.05	1.65	11.56	2.18	1.40	1.13	1.38	2.36	1.32
35000	0.70	4.11	1.66	7.26	1.95	17.97	2.66	1.78	1.25	1.96	3.22	1.74
35000	0.70	4.10	1.65	7.17	1.94	17.56	2.63	1.75	1.23	1.92	3.14	1.71
35000	0.70	4.10	1.64	7.09	1.92	17.12	2.59	1.71	1.22	1.87	3.04	1.67
35000	0.70	4.06	1.62	6.96	1.89	16.62	2.54	1.68	1.21	1.82	2.93	1.64
35000	0.70	4.01	1.59	6.80	1.85	16.06	2.48	1.65	1.20	1.77	2.83	1.60
35000	0.70	3.88	1.56	6.52	1.81	15.27	2.42	1.60	1.18	1.69	2.73	1.55
35000	0.70	3.65	1.52	6.07	1.75	14.18	2.33	1.55	1.17	1.60	2.61	1.48
35000	0.70	3.41	1.48	5.61	1.70	12.94	2.26	1.48	1.15	1.49	2.49	1.40
35000	0.70	3.13	1.44	5.07	1.65	11.58	2.17	1.39	1.13	1.37	2.35	1.31
35000	0.75	4.14	1.66	7.26	1.95	17.86	2.64	1.77	1.24	1.95	3.18	1.73
35000	0.75	4.13	1.65	7.19	1.93	17.51	2.61	1.74	1.23	1.91	3.10	1.70
35000	0.75	4.12	1.64	7.10	1.91	17.06	2.57	1.70	1.21	1.86	3.00	1.67
35000	0.75	4.08	1.62	6.96	1.88	16.54	2.52	1.67	1.20	1.81	2.90	1.63
35000	0.75	4.01	1.59	6.77	1.84	15.94	2.47	1.64	1.19	1.76	2.80	1.59
35000	0.75	3.87	1.55	6.48	1.80	15.16	2.40	1.60	1.18	1.68	2.70	1.54
35000	0.75	3.64	1.51	6.04	1.75	14.06	2.32	1.54	1.17	1.58	2.59	1.47
35000	0.75	3.42	1.48	5.61	1.70	12.91	2.25	1.47	1.15	1.49	2.48	1.40
35000	0.75	3.12	1.44	5.05	1.65	11.50	2.17	1.39	1.13	1.36	2.33	1.30
35000	0.80	4.16	1.66	7.26	1.94	17.75	2.63	1.75	1.24	1.93	3.14	1.72
35000	0.80	4.16	1.65	7.20	1.93	17.45	2.60	1.73	1.23	1.90	3.07	1.70
35000	0.80	4.14	1.63	7.10	1.90	16.98	2.56	1.69	1.21	1.85	2.97	1.66
35000	0.80	4.09	1.61	6.95	1.87	16.45	2.51	1.66	1.20	1.80	2.87	1.62
35000	0.80	4.00	1.58	6.73	1.83	15.79	2.45	1.63	1.19	1.74	2.77	1.58
35000	0.80	3.84	1.55	6.40	1.79	14.96	2.38	1.58	1.18	1.66	2.67	1.52
35000	0.80	3.63	1.51	6.01	1.74	13.94	2.31	1.53	1.16	1.57	2.57	1.46
35000	0.80	3.41	1.48	5.59	1.70	12.86	2.24	1.47	1.15	1.48	2.46	1.39
35000	0.80	3.12	1.44	5.04	1.64	11.43	2.16	1.38	1.13	1.36	2.32	1.30
35000	0.85	4.19	1.65	7.27	1.93	17.65	2.61	1.74	1.23	1.92	3.10	1.71
35000	0.85	4.19	1.65	7.22	1.92	17.39	2.59	1.72	1.22	1.89	3.04	1.69
35000	0.85	4.16	1.63	7.10	1.90	16.90	2.54	1.69	1.21	1.84	2.94	1.65
35000	0.85	4.10	1.60	6.94	1.86	16.35	2.49	1.65	1.20	1.79	2.84	1.61
35000	0.85	3.99	1.57	6.69	1.82	15.65	2.43	1.62	1.19	1.73	2.74	1.57
35000	0.85	3.83	1.54	6.37	1.78	14.81	2.36	1.57	1.18	1.65	2.65	1.51
35000	0.85	3.63	1.51	5.99	1.73	13.84	2.30	1.52	1.16	1.56	2.55	1.45
35000	0.85	3.40	1.47	5.55	1.69	12.76	2.23	1.46	1.15	1.47	2.44	1.38
35000	0.85	3.12	1.43	5.02	1.64	11.38	2.15	1.37	1.13	1.35	2.30	1.29

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ALT	MN	FNTOT	TSFC	WF	FNSAM	N1	N1C2	N2	N2C2	WAT2	BPR
40000	0.65	3343	0.7523	2515	18064	7510	8316	11264	12474	492	2.19
40000	0.65	3157	0.7426	2344	17060	7312	8097	11066	12255	487	2.20
40000	0.65	3003	0.7348	2206	16226	7139	7906	10910	12082	484	2.20
40000	0.65	2840	0.7286	2069	15349	7025	7779	10744	11898	479	2.21
40000	0.65	2668	0.7218	1926	14420	6885	7625	10570	11706	474	2.23
40000	0.65	2443	0.7210	1761	13200	6642	7356	10371	11485	465	2.27
40000	0.65	2158	0.7293	1574	11664	6388	7074	10152	11243	452	2.35
40000	0.65	1769	0.7536	1333	9559	6112	6769	9955	11025	434	2.45
40000	0.65	1352	0.8156	1103	7308	5783	6404	9673	10712	409	2.57
40000	0.70	3370	0.7687	2590	18209	7499	8253	11252	12384	491	2.19
40000	0.70	3204	0.7590	2432	17314	7322	8058	11085	12200	487	2.19
40000	0.70	3049	0.7504	2288	16476	7160	7880	10927	12026	483	2.20
40000	0.70	2879	0.7441	2142	15557	7042	7750	10761	11843	478	2.21
40000	0.70	2693	0.7389	1989	14550	6884	7577	10585	11650	473	2.23
40000	0.70	2457	0.7400	1818	13275	6647	7316	10391	11437	464	2.28
40000	0.70	2163	0.7484	1619	11669	6396	7040	10185	11209	451	2.35
40000	0.70	1796	0.7708	1384	9707	6140	6757	9984	10988	434	2.45
40000	0.70	1382	0.8317	1149	7467	5825	6411	9713	10691	410	2.57
40000	0.75	3387	0.7903	2676	18300	7489	8189	11253	12304	490	2.18
40000	0.75	3245	0.7790	2528	17536	7326	8011	11105	12142	486	2.18
40000	0.75	3093	0.7680	2375	16716	7179	7849	10945	11968	482	2.19
40000	0.75	2923	0.7601	2222	15795	7059	7718	10778	11785	478	2.20
40000	0.75	2727	0.7552	2059	14736	6866	7529	10602	11593	472	2.24
40000	0.75	2476	0.7583	1877	13381	6645	7266	10413	11385	462	2.29
40000	0.75	2173	0.7670	1667	11743	6410	7009	10222	11177	449	2.36
40000	0.75	1826	0.7878	1439	9869	6166	6742	10017	10952	433	2.45
40000	0.75	1422	0.8469	1205	7688	5880	6429	9749	10660	412	2.57
40000	0.80	3441	0.8052	2771	18595	7482	8124	11254	12220	489	2.17
40000	0.80	3297	0.7987	2634	17817	7332	7961	11126	12081	485	2.18
40000	0.80	3122	0.7919	2472	16868	7199	7817	10964	11906	481	2.18
40000	0.80	2959	0.7804	2309	15988	7075	7682	10797	11724	477	2.20
40000	0.80	2759	0.7736	2134	14909	6883	7474	10621	11532	470	2.24
40000	0.80	2514	0.7748	1948	13584	6653	7225	10435	11331	460	2.29
40000	0.80	2188	0.7851	1718	11825	6424	6975	10260	11141	447	2.36
40000	0.80	1863	0.8064	1502	10067	6196	6728	10046	10909	432	2.46
40000	0.80	1458	0.8615	1256	7877	5912	6420	9789	10630	412	2.57
40000	0.85	3513	0.8164	2875	18984	7471	8054	11260	12138	488	2.16
40000	0.85	3379	0.8130	2747	18256	7333	7905	11149	12019	485	2.17
40000	0.85	3192	0.8071	2576	17246	7220	7783	10985	11842	480	2.18
40000	0.85	3003	0.8004	2403	16226	7089	7642	10817	11660	476	2.20
40000	0.85	2776	0.7960	2215	15003	6881	7417	10640	11470	468	2.24
40000	0.85	2537	0.7940	2014	13708	6653	7172	10463	11279	458	2.30
40000	0.85	2228	0.8020	1786	12038	6445	6947	10291	11094	445	2.37
40000	0.85	1903	0.8237	1568	10285	6221	6706	10013	10169	431	2.46
40000	0.85	1495	0.8781	1313	8081	5946	6410	9829	10596	411	2.57

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ALT	MN	P3P2	T3T2	P3.2P2	T3.2T2	P4P2	T4T2	PDP2	TDT2	P7P2	T7T2	P8MP2
40000	0.65	3.91	1.66	7.01	1.96	17.62	2.68	1.78	1.25	1.95	3.30	1.74
40000	0.65	3.92	1.64	6.92	1.93	17.14	2.64	1.74	1.23	1.89	3.19	1.70
40000	0.65	3.91	1.63	6.84	1.91	16.73	2.60	1.71	1.22	1.85	3.09	1.66
40000	0.65	3.88	1.61	6.72	1.88	16.26	2.54	1.68	1.21	1.80	2.98	1.63
40000	0.65	3.83	1.58	6.57	1.85	15.72	2.49	1.64	1.20	1.75	2.88	1.59
40000	0.65	3.72	1.55	6.31	1.80	14.91	2.42	1.60	1.18	1.68	2.77	1.54
40000	0.65	3.53	1.51	5.93	1.75	13.87	2.35	1.54	1.17	1.58	2.67	1.47
40000	0.65	3.25	1.47	5.37	1.69	12.53	2.25	1.46	1.15	1.46	2.50	1.38
40000	0.65	2.95	1.42	4.81	1.64	11.03	2.16	1.37	1.13	1.34	2.36	1.29
40000	0.70	3.93	1.65	7.01	1.95	17.50	2.66	1.77	1.24	1.93	3.26	1.73
40000	0.70	3.94	1.64	6.93	1.93	17.08	2.62	1.73	1.23	1.89	3.16	1.69
40000	0.70	3.93	1.63	6.84	1.90	16.66	2.58	1.70	1.21	1.84	3.06	1.66
40000	0.70	3.89	1.61	6.72	1.87	16.18	2.53	1.67	1.21	1.79	2.96	1.62
40000	0.70	3.83	1.58	6.55	1.84	15.59	2.47	1.63	1.19	1.74	2.85	1.58
40000	0.70	3.71	1.55	6.28	1.80	14.78	2.41	1.59	1.18	1.66	2.75	1.53
40000	0.70	3.50	1.51	5.87	1.75	13.73	2.33	1.53	1.17	1.56	2.64	1.46
40000	0.70	3.25	1.47	5.37	1.69	12.47	2.25	1.46	1.15	1.46	2.49	1.38
40000	0.70	2.96	1.43	4.82	1.64	11.06	2.16	1.37	1.13	1.33	2.34	1.28
40000	0.75	3.95	1.65	7.00	1.94	17.39	2.65	1.76	1.24	1.92	3.22	1.72
40000	0.75	3.95	1.64	6.93	1.92	17.02	2.61	1.73	1.22	1.88	3.13	1.68
40000	0.75	3.94	1.62	6.84	1.90	16.58	2.57	1.69	1.21	1.83	3.03	1.65
40000	0.75	3.91	1.60	6.71	1.87	16.09	2.52	1.66	1.20	1.78	2.93	1.61
40000	0.75	3.83	1.58	6.52	1.83	15.46	2.46	1.63	1.19	1.72	2.83	1.57
40000	0.75	3.69	1.54	6.23	1.79	14.62	2.40	1.58	1.18	1.64	2.73	1.52
40000	0.75	3.48	1.50	5.81	1.74	13.59	2.32	1.52	1.16	1.55	2.61	1.45
40000	0.75	3.25	1.47	5.36	1.69	12.40	2.24	1.45	1.14	1.45	2.48	1.37
40000	0.75	2.99	1.43	4.86	1.64	11.09	2.16	1.37	1.13	1.33	2.33	1.28
40000	0.80	3.98	1.65	7.01	1.93	17.29	2.63	1.74	1.23	1.91	3.18	1.70
40000	0.80	3.98	1.64	6.94	1.92	16.95	2.60	1.72	1.22	1.87	3.10	1.68
40000	0.80	3.96	1.62	6.84	1.89	16.50	2.55	1.69	1.21	1.82	3.00	1.64
40000	0.80	3.91	1.60	6.70	1.86	16.00	2.50	1.65	1.20	1.77	2.89	1.60
40000	0.80	3.83	1.57	6.49	1.82	15.32	2.44	1.62	1.19	1.71	2.80	1.56
40000	0.80	3.68	1.54	6.19	1.78	14.49	2.38	1.57	1.18	1.63	2.70	1.50
40000	0.80	3.46	1.50	5.75	1.73	13.43	2.30	1.51	1.16	1.53	2.58	1.43
40000	0.80	3.25	1.46	5.34	1.69	12.33	2.23	1.44	1.14	1.44	2.46	1.36
40000	0.80	2.99	1.43	4.85	1.64	11.04	2.15	1.36	1.12	1.32	2.32	1.27
40000	0.85	4.00	1.64	7.01	1.93	17.18	2.61	1.73	1.23	1.89	3.13	1.69
40000	0.85	4.00	1.64	6.95	1.91	16.88	2.58	1.71	1.22	1.86	3.06	1.67
40000	0.85	3.97	1.61	6.83	1.88	16.41	2.54	1.68	1.21	1.81	2.96	1.63
40000	0.85	3.92	1.59	6.69	1.85	15.89	2.48	1.65	1.20	1.76	2.86	1.60
40000	0.85	3.82	1.56	6.45	1.81	15.17	2.43	1.61	1.19	1.69	2.77	1.55
40000	0.85	3.65	1.53	6.12	1.77	14.31	2.36	1.56	1.17	1.61	2.67	1.49
40000	0.85	3.45	1.49	5.72	1.72	13.31	2.29	1.50	1.16	1.52	2.56	1.42
40000	0.85	3.25	1.46	5.33	1.68	12.25	2.22	1.44	1.14	1.43	2.45	1.36
40000	0.85	3.00	1.43	4.63	1.63	10.99	2.15	1.35	1.12	1.32	2.30	1.27

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE
ESTIMATED THRUST AND FUEL FLOW CORRECTION FACTORS

	LPC EXIT BLEED		HPC INTER STAGE BLEED		HPC EXIT BLEED		FAN DUCT BLEED		HIGH ROTOR POWER EXTR		INLET DUCT LOSS	
FNSAM	CBL1	CBL1*	CBL2	CBL2*	CBL3	CBL3*	CBL4	CBL4*	CPX CORR	CPX* CORR	CD	CD*
									HPX(REF)=1400			
FLIGHT MACH NUMBER = 0.0												
17096	1.43	1.06	1.77	1.24	2.47	1.51	0.59	0.05	0.04	0.01	1.03	0.0
16175	1.55	1.14	2.10	1.48	2.75	1.78	0.20	-0.26	0.07	0.03	1.22	0.0
14793	1.46	1.05	2.38	1.64	3.02	1.92	0.24	-0.27	0.10	0.05	1.27	0.0
13294	1.77	1.23	2.65	1.79	3.44	2.19	0.09	-0.32	0.13	0.07	1.60	0.0
11741	1.78	1.23	2.70	1.79	3.53	2.15	0.03	-0.33	0.18	0.10	1.73	0.0
10330	1.75	1.11	2.83	1.71	3.68	2.05	0.08	-0.30	0.25	0.13	2.05	0.0
9039	1.77	0.98	2.98	1.64	3.66	1.81	0.27	-0.14	0.36	0.19	2.54	0.0
7611	1.26	0.62	2.76	1.49	3.40	1.62	0.27	-0.08	0.51	0.29	2.60	0.0
6423	1.16	0.61	2.32	1.10	3.60	1.68	0.22	-0.15	0.80	0.48	3.41	0.0
5068	1.36	0.68	2.31	1.13	4.58	2.11	0.34	-0.07	1.26	0.79	4.26	0.0
FLIGHT MACH NUMBER = 0.2												
14503	1.79	1.15	2.18	1.35	2.83	1.56	0.91	0.10	0.05	0.01	1.49	0.0
13544	1.78	1.14	2.39	1.49	3.08	1.74	0.46	-0.22	0.07	0.03	1.34	0.0
12287	1.87	1.15	2.89	1.78	3.56	2.05	0.68	-0.11	0.11	0.05	1.54	0.0
10881	2.08	1.25	3.16	1.86	3.94	2.21	0.47	-0.22	0.15	0.07	1.84	0.0
9426	2.07	1.19	3.16	1.83	3.94	2.09	0.30	-0.33	0.20	0.10	2.03	0.0
8215	1.97	1.10	3.16	1.72	3.98	2.00	0.48	-0.21	0.26	0.12	2.22	0.0
7144	1.55	0.71	3.17	1.54	3.72	1.60	0.54	-0.17	0.35	0.17	2.50	0.0
6098	1.35	0.52	2.83	1.25	3.70	1.43	0.47	-0.18	0.50	0.25	2.86	0.0
4916	1.57	0.70	2.72	1.14	4.15	1.71	0.57	-0.19	0.80	0.41	3.74	0.0

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ICAO MODEL ATMOSPHERE
ESTIMATED THRUST AND FUEL FLOW CORRECTION FACTORS

	LPC EXIT BLEED		HPC INTER STAGE BLEED		HPC EXIT BLEED		FAN DUCT BLEED		HIGH ROTOR POWER EXTR		INLET DUCT LOSS	
FNSAM	CBL1	CBL1'	CBL2	CBL2'	CBL3	CBL3'	CBL4	CBL4'	CPX CORR	CPX' CORR	CD	CD'
									HPX(REF)=1400			
FLIGHT MACH NUMBER = 0.4												
13098	2.18	1.21	2.80	1.53	3.10	1.49	1.47	0.26	0.07	0.02	1.32	0.0
11942	1.79	0.95	2.62	1.42	2.89	1.37	0.90	-0.14	0.06	0.03	1.40	0.0
10631	1.85	0.98	2.98	1.62	3.41	1.68	1.02	-0.09	0.11	0.05	1.64	0.0
9472	1.54	0.67	3.05	1.53	3.46	1.55	0.68	-0.32	0.14	0.06	1.77	0.0
8277	1.82	0.76	3.43	1.66	4.07	1.79	0.77	-0.29	0.20	0.09	2.18	0.0
6588	1.46	0.55	2.88	1.27	3.72	1.52	0.60	-0.42	0.23	0.10	2.30	0.0
6129	1.54	0.53	2.71	1.06	3.85	1.48	0.86	-0.35	0.29	0.12	2.60	0.0
5206	1.68	0.68	2.90	1.07	4.07	1.43	1.02	-0.25	0.40	0.17	3.09	0.0
4186	1.87	0.57	3.53	1.35	4.80	1.67	1.39	-0.10	0.63	0.28	4.04	0.0
FLIGHT MACH NUMBER = 0.6												
14896	1.47	0.75	1.85	0.90	2.30	0.96	1.45	0.16	0.03	0.01	1.06	0.0
14446	1.68	0.86	1.99	0.96	2.47	1.04	1.28	0.04	0.04	0.01	1.12	0.0
13477	1.68	0.80	2.54	1.24	2.66	1.20	1.46	0.10	0.06	0.02	1.19	0.0
12423	1.81	0.80	2.75	1.31	3.13	1.28	1.03	-0.24	0.08	0.03	1.42	0.0
11102	1.58	0.60	2.81	1.30	3.26	1.33	1.13	-0.25	0.11	0.04	1.53	0.0
9776	1.81	0.62	2.87	1.17	3.75	1.42	0.98	-0.51	0.15	0.07	1.83	0.0
8511	1.91	0.66	2.82	1.05	3.93	1.45	1.25	-0.38	0.21	0.10	2.02	0.0
7013	2.44	0.91	3.43	1.29	4.73	1.76	1.32	-0.43	0.31	0.14	2.63	0.0
5267	2.00	0.52	3.63	1.14	4.74	1.43	1.96	-0.24	0.51	0.23	3.05	0.0

PRATT AND WHITNEY AIRCRAFT
JT8D-109 TURBOFAN ENGINE ESTIMATED PERFORMANCE
ICAO MODEL ATMOSPHERE
ESTIMATED THRUST AND FUEL FLOW CORRECTION FACTORS

	LPC EXIT BLEED		HPC INTER STAGE BLEED		HPC EXIT BLEED		FAN DUCT BLEED		HIGH ROTOR POWER EXTR		INLET DUCT LOSS	
FNSAM	CBL1	CBL1*	CBL2	CBL2*	CBL3	CBL3*	CBL4	CBL4*	CPX CORR	CPX* CORR	CD	CD*
									HPX(REF)=1400			

FLIGHT MACH NUMBER = 0.8

17150	1.45	0.70	1.62	0.74	1.85	0.67	1.58	0.17	0.02	0.00	0.83	0.0
16591	1.38	0.70	1.68	0.83	1.94	0.78	1.53	0.17	0.02	0.01	0.78	0.0
15646	1.73	0.69	1.97	0.95	2.41	1.01	1.37	-0.01	0.04	0.01	1.03	0.0
14662	1.76	0.61	2.55	1.22	2.84	1.18	1.77	0.16	0.06	0.02	1.11	0.0
13383	1.86	0.74	2.68	1.21	3.09	1.24	1.33	-0.21	0.08	0.04	1.32	0.0
11986	1.73	0.61	2.71	1.15	3.28	1.27	1.46	-0.26	0.12	0.06	1.40	0.0
10572	1.91	0.64	2.76	1.06	3.69	1.40	1.31	-0.53	0.20	0.10	1.61	0.0
8915	2.07	0.64	3.15	1.08	3.91	1.27	2.18	-0.22	0.33	0.16	1.92	0.0
6815	2.68	0.63	3.91	1.13	5.19	1.42	3.27	-0.13	0.59	0.28	2.62	0.0

FLIGHT MACH NUMBER = 1.0

19516	1.60	0.71	1.60	0.75	2.27	0.83	1.81	0.17	0.02	0.01	0.93	0.0
18963	1.66	0.65	2.23	0.99	2.61	1.02	1.90	0.17	0.02	0.01	1.05	0.0
17538	1.93	0.87	2.40	1.07	2.55	0.92	1.77	0.05	0.04	0.02	1.00	0.0
16434	2.10	0.93	2.83	1.31	3.11	1.26	1.89	0.07	0.05	0.02	1.10	0.0
14760	1.94	0.72	2.70	1.13	3.07	1.14	1.71	-0.16	0.07	0.04	1.22	0.0
13265	2.09	0.74	2.81	1.11	3.66	1.44	1.91	-0.22	0.11	0.06	1.34	0.0
11514	2.09	0.66	2.81	1.04	3.75	1.37	1.86	-0.40	0.16	0.08	1.46	0.0
9781	2.00	0.60	3.26	1.17	3.71	1.26	2.65	-0.17	0.24	0.12	1.42	0.0
7516	2.38	0.45	3.57	0.90	4.69	1.24	3.70	-0.13	0.39	0.18	2.27	0.0

APPENDIX B

LIST OF SYMBOLS

LIST OF SYMBOLS

AF/AE	Engine Area Ratio (Fan/Engine) at Tailpipe Mixing Plane
Aj	Jet Nozzle Area
CV	Gross Thrust Coefficient
EGT	Exhaust Gas Temperature (TT7)
FEGV	Fan Exit Guide Vane
FN	Net Thrust
HPC	High Pressure Compressor
HPX	Horsepower Extraction
Kc	TSFC Correction Factor
Kh	Specific Humidity Correction Factor for WF and TSFC
LHV	Lower Heating Value
LPC	Low-Pressure Compressor
MN (Mn)	Mach No.
N1	Low-Rotor Speed
N2	High-Rotor Speed
O/L	Operating Line
PAMB (Pamb)	Ambient Pressure
PLA	Power Lever Angle
PO	Standard Sea Level Pressure
PR	Pressure Ratio
PS3	Low-Pressure Compressor Discharge Static Pressure
PS4	High-Pressure Compressor Discharge Static Pressure
PT	Total Pressure
PT2	Engine Inlet Total Pressure
PT2.4	Low-Pressure Compressor Inlet Total Pressure
PT3	Low-Pressure Compressor Discharge Total Pressure
PT4	High-Pressure Compressor Discharge Total Pressure
PT7	Low-Pressure Turbine Discharge Total Pressure
PT7F	Fan Duct Exit Total Pressure
PT8	Exhaust Nozzle Discharge Total Pressure
S/L	Surge Line
SLS	Sea Level Static
SM	Surge Margin

LIST OF SYMBOLS (Cont'd)

SPR	Surge Pressure Ratio
SPRC	Surge Pressure Ratio (Undistorted)
SPRD	Surge Pressure Ratio (Distorted)
STO	Overall Turbine (Efficiency)
TEGV	Turbine Exit Guide Vane
TSFC	Thrust Specific Fuel Consumption
TT2	Engine Inlet Total Temperature
TT5	High-Pressure Turbine Inlet Total Temperature
TT7	Low-Pressure Turbine Discharge Total Temperature
WAE	Core Engine Airflow
WAT	Total Airflow
WATC2	Corrected Total Airflow
WF/PB (Wf/Pb)	Fuel Flow/Burner Pressure
δ	Relative Absolute Pressure
θ	Relative Absolute Temperature
η	Efficiency