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<td>Horsepower and Bleed Air Extractions</td>
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1.0 **SCOPE**

This specification defines the installed performance of the 650-pound-per-second Pratt & Whitney JT12A-20B engine in the Boeing Model 733-394 airplane. Performance data are presented for the initial service (1900°F) engine and the basic (2200°F) engine. The estimated inlet drag values used for the determination of airplane performance characteristics are also specified.

System performance requirements established herein are design objectives to be applied to the prototype airplanes. Application of these requirements to production airplane design will be established after prototype flight testing.
2.0 APPLICABLE DOCUMENTS

The following documents are to be used in conjunction with this specification:

- Pratt & Whitney Engine Performance Data Decks 5173 Low TIT and 5172 High TIT, September 15, 1965

The documents listed below are Boeing publications:

- D6-19907 Power Plant Installation Performance Specification
- D6-19909 Air Induction System Performance Specification
- D6-19905 Air Induction System Performance Specification
- D6-19906 Propulsion Control System Performance Specification
3.0 PROPULSION SYSTEM DESCRIPTION

3.1 ENGINE
The Pratt & Whitney JT9D-208 engine is a twin-spool, axial-flow, turbofan engine incorporating a full-length fan duct with duct heater, a variable-geometry nozzle for the fan duct, a blow-in-door, convergent-divergent ejector nozzle, and a thrust reverser. A detailed engine description with special features required for installation is contained in the Pratt & Whitney Model Specification. The airplane engine installation is described in Boeing Document D6-19907, Power Plant Installation Performance Specification.

3.2 PROPULSION POD
The propulsion pod incorporates a variable centerbody air induction system, an unpressurized nacelle, remotely mounted aircraft accessories, and an exhaust nozzle system with thrust reverser. The air induction system is described in Boeing Document D6-19909, Air Induction System Performance Specification.

3.3 CONTROL
Installed performance is based on air induction control system and engine control system described in Boeing Documents D6-19905, Air Induction Control System Performance Specification and D6-19908, Propulsion Control System Performance Specification, respectively.
4.0 INSTALLED ENGINE PERFORMANCE

4.1 CALCULATION PROCEDURE

The installed engine performance is calculated by the use of Pratt & Whitney Performance Data Deck (see Section 2.0). The data deck is capable of accurate calculation of engine performance, including the installed effects of inlet recover, nozzle coefficient, and bleed and power extraction, within engine limits. For the performance calculations the low airflow schedule was used.

a. Performance Assumptions

The engine performance determination was made under the following assumptions:


• Fuel: Performance is based on fuel specification ASTM D1657 Jet A or A-I Type Aviation kerosene, conforming to Pratt & Whitney Fuel Specification PA 533, with a lower heating value of 15,500 Btu per pound.

b. Inlet Total Pressure Recovery

The inlet total pressure recovery used to calculate installed engine performance is shown in Fig. 1.

c. Nozzle Coefficient

The nozzle thrust coefficient used to calculate installed engine performance is shown in Fig. 2. External boattail drag is included in this thrust coefficient. The nozzle thrust coefficients are based on a secondary corrected cooling flow

\[
\frac{W_s}{V_p} \sqrt{\frac{R_s}{R_p}}
\]

equal to 3 percent for duct-heater temperatures above 2750°F and a secondary corrected cooling flow of 2 percent for duct heater temperatures below 2750°F. The ram drag of the secondary air is included in the thrust coefficients shown on Fig. 2.

d. Horsepower Extraction

Table A lists the horsepower extracted from the engine for various flight conditions to supply power for aircraft systems.

e. Engine Airbleed

Table A lists the airbleed extracted from the high-pressure compressor for various flight conditions to supply high-pressure air for aircraft systems.
Fig. 1 Installed Inlet Drag Coefficients and Inlet Ram Recovery
CONFiDENTiAL

JTF17A-20B ~ 1900°F / 2000°F RATING

\[ C_{\text{PR}} = \frac{\text{EJECTOR CROSS THRUST} - \text{(EXTERNAL PRESSURE DRAG & FULL SECONDARY RIM DRAG)}}{\text{IDEAL GROSS THRUST OF ENGINE AND FAN STREAMS}} \]

MIN AUG | MA' DAY | MIN AUG | MAX AUG

\[ C_{\text{PR}} \]

0.5 | 1.0 | 1.5 | 2.0 | 2.5

Fig. 2 Thrust Coefficient
Table A: Horsepower and Blood Air Extractions

<table>
<thead>
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<th>Airplane Operating Condition</th>
<th>Horsepower per Engine</th>
<th>Blood Air (pounds per second per engine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takeoff</td>
<td>325</td>
<td>1.6</td>
</tr>
<tr>
<td>Climb and Acceleration</td>
<td>350</td>
<td>1.6</td>
</tr>
<tr>
<td>Supersonic Cruise</td>
<td>300</td>
<td>1.3</td>
</tr>
<tr>
<td>Holding at Mach 0.4, 15,000 feet</td>
<td>300</td>
<td>2.8</td>
</tr>
<tr>
<td>Cruise to Alternate at Mach 0.8, 36,150 feet</td>
<td>300</td>
<td>2.8</td>
</tr>
<tr>
<td>Descent</td>
<td>250</td>
<td>1.4</td>
</tr>
</tbody>
</table>

f. Engine Operating Envelope

The standard day operating envelope for the engine is shown in Fig. 3.

4.2 ENGINE PERFORMANCE CURVES (1900°F)

Installed-engine performance curves for the initial service (1900°F) engine for standard and nonstandard day are shown on Figs. 4 through 16.
Fig. 3 Engine Operating Envelope
CONFIDENTIAL

JTF 17A-20B ~ 1500°F/2000°F RATING

STANDARD DRY
MAX AUGMENTED

SEAL LEVEL
4000 FT.
6000 FT.

SFC
2.2
2.0
1.8
1.6

SEA LEVEL
4000 FT.
6000 FT.

SFC
1.4
1.2
1.0

Fig. 4 Takeoff Net Thrust and SFC - Standard Day
Fig. 5 Takeoff Net Thrust and SFC - Standard Day + 21°F
CONFIDENTIAL

JTF 17A - 200°F/2000°F RATING

STANDARD DRY +40°F
MAX AUGMENTED

STANDARD DAY +40°F
MIN AUGMENTED

Fig. 6: Takeoff Thrust and SFC - Standard Day + 40°F

CONFIDENTIAL
Fig. 7 Climb and Acceleration Net Thrust and SFC – Standard Day
Fig. 8. Climb and Acceleration Thrust and SFC Standard Day + 15°F
Fig. 10 Cruise Hot Thrust and SFC - Standard Day + 15°F
Fig. 11 SFC versus Thrust - Standard Day, Sea Level
Fig. 12 SFC versus Thrust - Standard Day, 15,000 Ft.
Fig. 14 SFC versus Thrust – Standard Day, 36,150 Ft.
Fig. 15 SFC versus Thrust - Standard Day, 45,000 Ft.
Fig. 16 Normal and Emergency Descent - Thrust and Fuel Flow - Standard Day
5.0 PROPULSION SYSTEM DRAG

5.1 INLET DRAG

Inlet drag is included in the airplane drag build-up for airplane performance calculations. The inlet drag includes spillage, cowling friction, boundary layer bleed, and aircraft air-conditioning bleed drag. Table 9 lists the airbled extracted from the inlet for various flight conditions to supply high-pressure air for air conditioning.

Fig. 1 shows the inlet drag for maximum dry and augmented power settings during standard and hot-day operation. The excess air drag at partial power when engine airflow demand is reduced is also shown on Fig. 1.

The inlet drag during normal and emergency descent operation at idle power settings is shown in Fig. 17.

5.2 NOZZLE DRAG

No correction to airplane drag is made for nozzle external drag because this drag is included in the nozzle thrust coefficient.
Fig. 17 Installed Inlet Drag Coefficients – Idle Descent
APPENDIX

JTF17A-20B  2200° F/2300° F

The appendix (Figs. A-1 through A-15) presents the installed engine performance data for the "tactical" P&W JTF17A-20B turbofan engine rated at 2200°F cruise turbine-inlet temperature.

The airflow schedule and inlet data for this engine are the same as for the 1900°F engine.
Fig. A-1  Takeoff Net Thrust and SFC - Standard Day
CONFIDENTIAL

JTF 17A-208 ~ 7,200°F/2300°F RATING

STANDARD DAY + 2°F
MAX. AUGMENTED

SFC
2.2
2.0
1.8
1.6

SEA LEVEL

4000 FT.

8000 FT.

40
42
44
46
48
50

SEA LEVEL

4000 FT.

8000 FT.

36
34
32
30
28
26
24

F T0 ~ KNOTS

0 50 100 150 200 250

Fig. A-2 Takeoff Hot Thrust and SFC - Standard Day + 2°F
CONFIDENTIAL

JTF-17A-20B ~ 2200°F / 2500°F RATING

STANDARD DAY + 40°F
MAX AUGMENTED

Vto ~ KNOTS

Fig. A-3 Takeoff Net Thrust and SFC - Standard Day + 40°F

CONFIDENTIAL
Fig. A-4: Climb and Acceleration Net Thrust and SFC - Standard Day
Fig. A-5. Climb and Acceleration Net Thrott and SFC - Standard Day + 15°F
JTF 17A-20B ~ 2200°F/2300°F RATING

MACH 2.63 CRUISE
STANDARD DAY + 15°F
Tₚ LIMIT = 500°F

AUGMENTED

Fig. A-7 Cruise Net Thrust and SFC - Standard Day + 15°F
JTF 11A-20B ~ 2200°F/2300°F RATING

STANDARD DAY
25,000 FT.

Fig. A-10 SFC versus Thrust Standard Day, 25,000 ft.