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# PHASE III
# BOEING MODEL 2707

SUPERSONIC TRANSPORT DIVISION

FAA SECURITY CONTROL
NO. 68/562 A-24

D6A10111-1

**CONFIDENTIAL**

*Phase III*

*Supersonic Transport Development Program*

**BOEING MODEL 2707**

# PROPULSION PERFORMANCE SPECIFICATION (GENERAL ELECTRIC) (U)

D6A10111-1

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APPROVED BY CA Grotz APPROVED BY Fred A. Maxam

**Contract FA-SS-66-5**

*Prepared for*

**FEDERAL AVIATION ADMINISTRATION**

*Office of Supersonic Transport Development Program*

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## NOTICES

# REVISION RECORD

Original release.

June 30, 1966

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Document completely revised to reflect the Phase III Proposal Configuration of the 2707.

September 6, 1966

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Document extensively revised to (a) reflect the 2707-100 configuration, and (b) incorporate revisions requested by the FAA as documented.

December 31, 1966

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CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (Cont.)

ILLUSTRATIONS (Cont.)



TABLES

1. SCOPE

This specification establishes the requirement for the performance and method of calculation of the 2707-100 (GE) propulsion system. The General Electric GE4/J5P engine performance data is the primary data for the propulsion performance specification. The body of this specification, together with Supplement I, defines the prototype propulsion subsystem performance and method of calculation. The body of this specification, together with Supplement II, defines the production propulsion subsystem performance.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue hown form a part of this specification to the extent specified herein. In the event of conflict between documents listed herein, with the exception of the Engine/Airframe Technical Agreement (D6A10198-1), the requirements specified by the specification shall take precedence.

2.1 Specification.

| | | |
|---|---|---|
| A.S.T.M. D1655-64T | 1964 | Fuel Specification |

2.2 Standards.

None

2.3 Other Publications.

| | | |
|---|---|---|
| NACA Report No. 1135 | 1953 | Equations, Tables and Charts for Compressible Flow |
| NACA Report No. 1253 | 1955 | A correlation by means of Transonic Similarity Rules of Experimentally Determined Characteristics of a Series of Symmetrical and Cambered Wings of Rectangular Plan Form. |
| NACA Report No. 1094 | 1952 | An experimental investigation of transonic flow past two-dimensional wedge and circular arc sections using Mach-Zehnder interferometer. |
| Federal Aviation Agency | 30 June 1966 | Phase III Request for Proposal |
| U. S. Government Printing Office | 1962 | U. S. Standard Atmosphere |

| | | |
|---|---|---|
| General Electric Co. | Aug 1966 | Engine Performance Deck GE4/J5P Engine R66 FPD 228E |
| General Electric Co. | Aug 1966 | Exhaust Nozzle Performance Deck GE4/J5P Nozzle R66 FPD 228N |
| General Electric Co. | 6 Sept 1966 | Engine Model Specification No. E-2056 |
| M.I.T. Technical Report No. 1 - Zdenak Kopal | 1947 | Tables of Supersonic Flow Around Cones |
| McGraw Hill E. A. Bonney | 1950 | Engineering Supersonic Aerodynamics |

<u>Boeing</u>

| | | |
|---|---|---|
| D6A10089-1 | 31 Dec 1966 | Accessory Drive Subsystem |
| D6A10113-1 | 31 Dec 1966 | Aircraft Engine Installation Subsystem |
| D6A10114-1 | 31 Dec 1966 | Air Induction Subsystem |
| D6A10116-1 | 31 Dec 1966 | Fuel Subsystem |
| D6A10121-1 | 31 Dec 1966 | Environmental Control |
| D6A10117-1 | 31 Dec 1966 | Engine Inlet Anti-Icing Subsystem |
| D6A10198-1 | 31 Dec 1966 | Engine/Airframe Technical Agreement |
| D6-7842 | Feb 1963 | Pressures on Bodies of Revolution at Supersonic Speeds |
| D6-2559 | Oct 1964 | SST Exhaust Nozzle Boattail Drag Tests at Subsonic and Transonic Conditions |

3. REQUIREMENTS

3.1 Performance.

3.1.1 Functional Characteristics. The functions of propulsion performance are:

a. To deliver thrust with minimum fuel consumption and minimum inlet drag.

b. To transmit torque to the accessory drive subsystem.

c. To deliver air to the environmental control subsystem, and engine inlet anti-icing subsystem.

3.1.1.1 Engine Performance Characteristics. The performance characteristics of the installed engine shall be as shown in Table I. The installed engine net thrust and specific fuel consumption for the standard day and non-standard day for various altitudes, Mach numbers, and power settings are shown in Figs. 1 through 13. The terms constituting net thrust and specific fuel consumption are shown as subparagraphs hereunder and in logical sequence.

3.1.1.1.1 Performance Criteria. The installed engine performance for all power levels shall be calculated by use of GE4/J5P Engine Performance data deck and Exhaust Nozzle Performance data deck supplied by the General Electric Co. The installed net thrust and specific fuel consumption curves shall include the effects of inlet total pressure recovery, compressor discharge air bleed, shaft horsepower extraction, and exhaust nozzle secondary airflow within the engine design and operation envelope shown in Fig. 14. The data decks define production engine estimated performance representing maximum fuel flow and minimum net thrust for all power settings from idle to maximum augmentation. Engine performance is based on U. S. Standard Atmosphere, 1962, Geometric Altitude, and the use of a fuel conforming to Fuel Specification A.S.T.M. D1655-64T Jet A or A-1 Type aviation kerosene. The minimum lower heating value of this fuel is 18,400 B.T.U/lb and is used in all performance data presented herein. The nozzle secondary airflow used in calculating engine performance is shown in Fig. 16.

3.1.1.1.1.1 Inlet Total Pressure Recovery. The inlet total pressure recovery used in calculating engine performance is shown in Fig. 15.

3.1.1.1.1.2 Horsepower Extraction. Table II lists the average horsepower extracted from the engine to supply power for aircraft systems.

3.1.1.1.1.3 Engine Air Bleed. The average amounts of airbleed required from the engine compressor to meet the average requirements of the environmental control subsystem are given in Table I. Engine and inlet anti-icing bleed is of a short term nature and is omitted from engine performance.

Table I. Engine Performance

| Power setting | Pressure altitude (ft) | Ambient temp | Mach Number | Inlet Ram Recovery | Net thrust (lb) | S F C (lb/hr/lb) | Airflow (lb/sec) | Power Extraction (hp) | Secondary air (lb/sec) | Bleed air (lb/sec) |
|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Augmented | 0 | Std | 0 | 0.96 | 59,600 | 1.75 | 596 | 450 | 72 | 0 |
| Maximum Non-Augmented | 0 | Std | 0 | 0.96 | 46,400 | 1.07 | 595 | 450 | 30 | 0 |
| Maximum Augmented | 0 | Std +40°F | 0 | 0.96 | 51,400 | 1.80 | 534 | 450 | 73 | 0 |
| Maximum Non-Augmented | 0 | Std +40°F | 0 | 0.96 | 40,100 | 1.08 | 534 | 450 | 32 | 0 |
| Maximum Augmented | 45,000 | Std | 1.2 | 0.986 | 22,300 | 1.73 | 221 | 450 | 13 | 0 |
| Maximum Augmented | 45,000 | Std +10°C | 1.2 | 0.986 | 21,300 | 1.77 | 217 | 450 | 13 | 0 |
| Partial Augmented | 65,000 | Std | 2.7 | 0.91 | 15,000 | 1.51 | 291 | 450 | 8.8 | 0 |
| Partial Augmented | 65,000 | Std +10°C | 2.61 | 0.914 | 15,000 | 1.63 | 253 | 450 | 24 | 0 |
| Partial Non-Augmented | 36,150 | Std | 0.85 | 0.99 | 5,000 | 1.11 | 163 | 450 | 13 | 0 |
| Partial Non-Augmented | 15,000 | Std | 0.50 | 0.988 | 5,000 | 1.35 | 235 | 450 | 17 | 0 |
| Idle | 0 | Std | 0 | 0.97 | 1,530 | * | 139 | 300 | 7.0 | 2.1 |
| Idle | 50,000 | Std | 1.2 | 0.986 | -760 | ** | 87 | 500 | 5.7 | 1.85 |
| Maximum Reverse | 0 | Std | 0 | 0.96 | 23,000 | *** | 595 | 550 | - | 2.1 |

* $W_f$ = 4,500 lb/hr

** $W_f$ = 1,440 lb/hr

*** $W_f$ = 49,600 lb/hr

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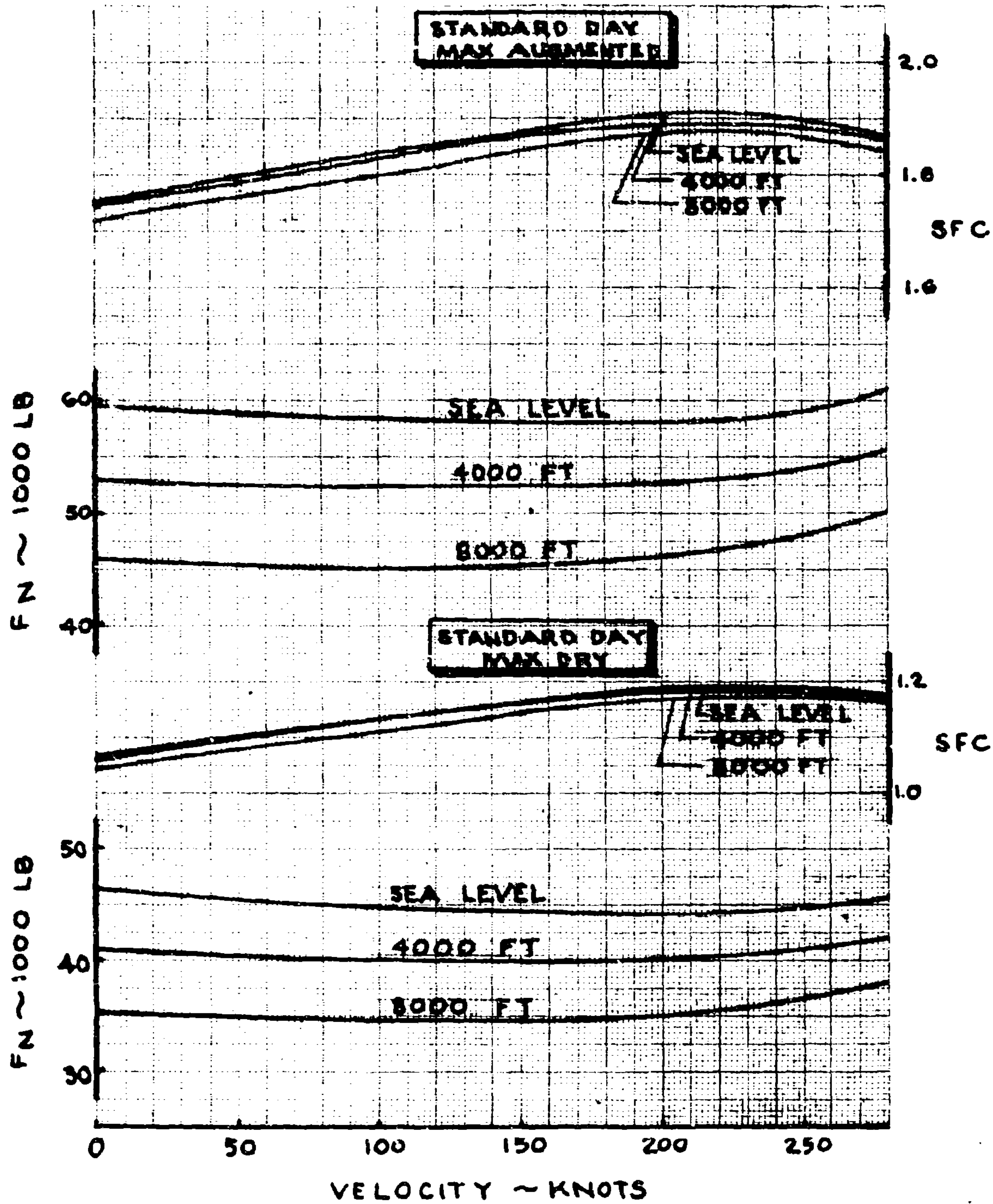


*Figure 1. Takeoff Thrust and SFC, Standard Day*

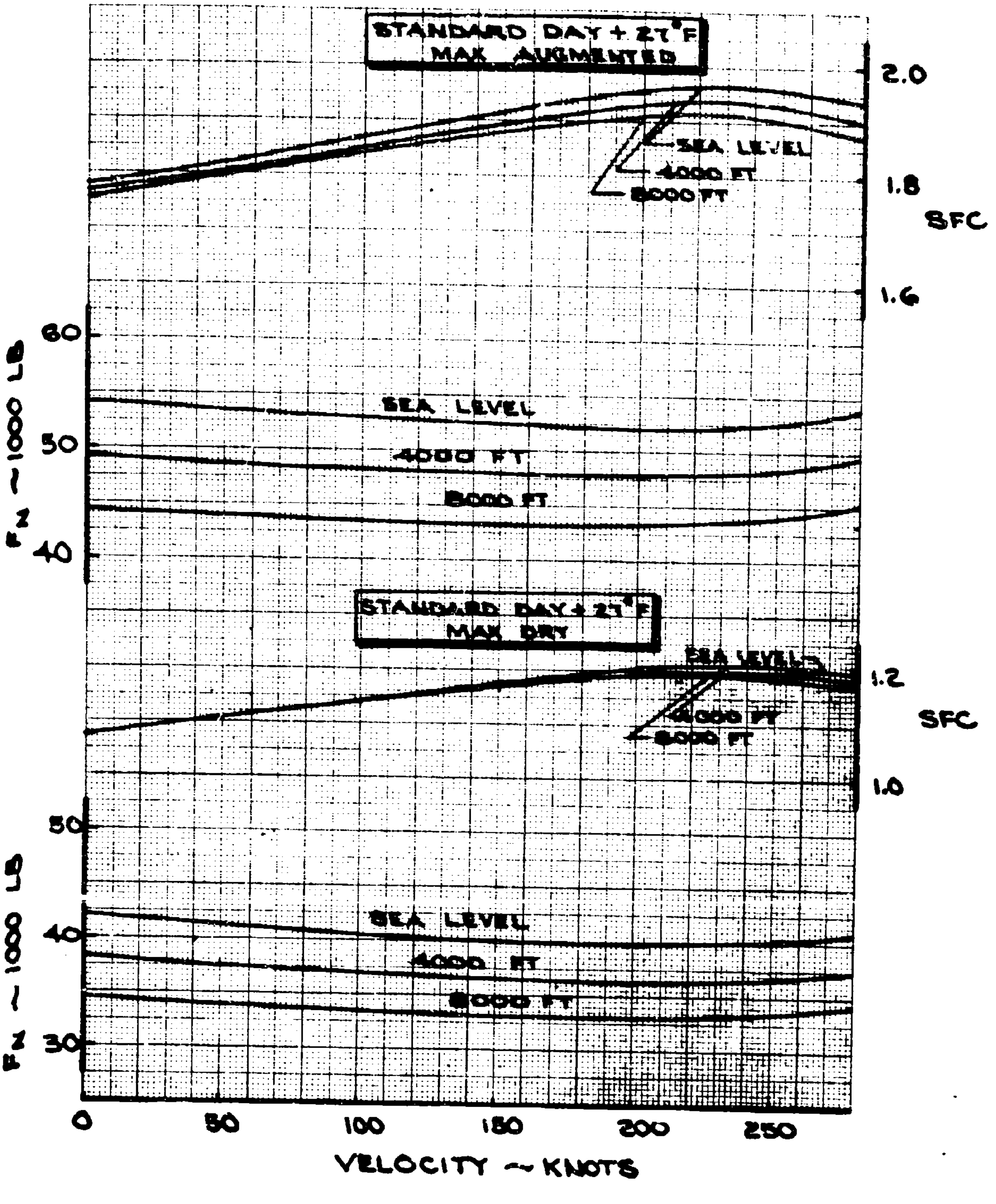


*Figure 2. Takeoff Thrust and SFC, Standard Day + 27°F*

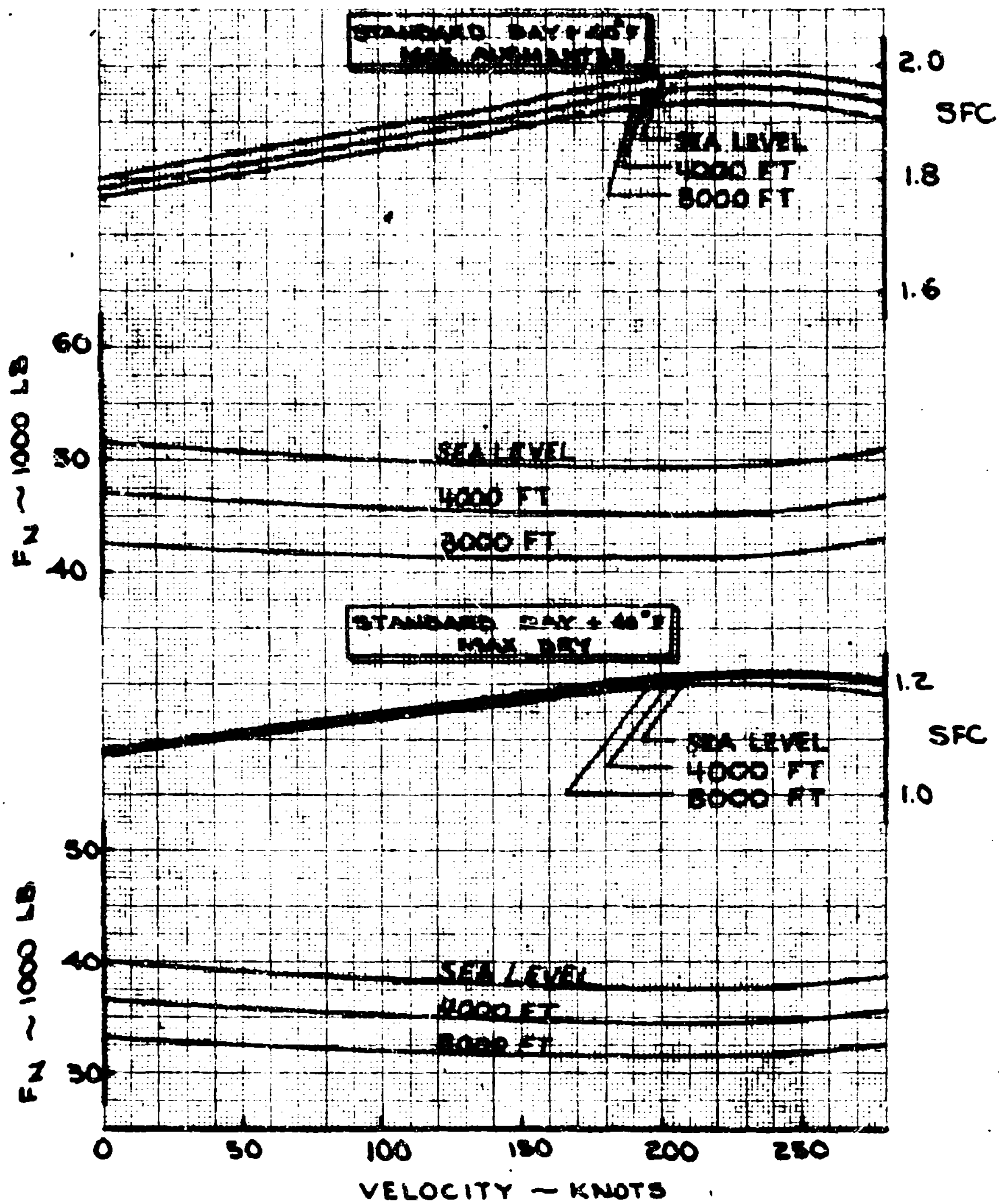


*Figure 3. Takeoff Thrust and SFC - Standard Day + 40° F*

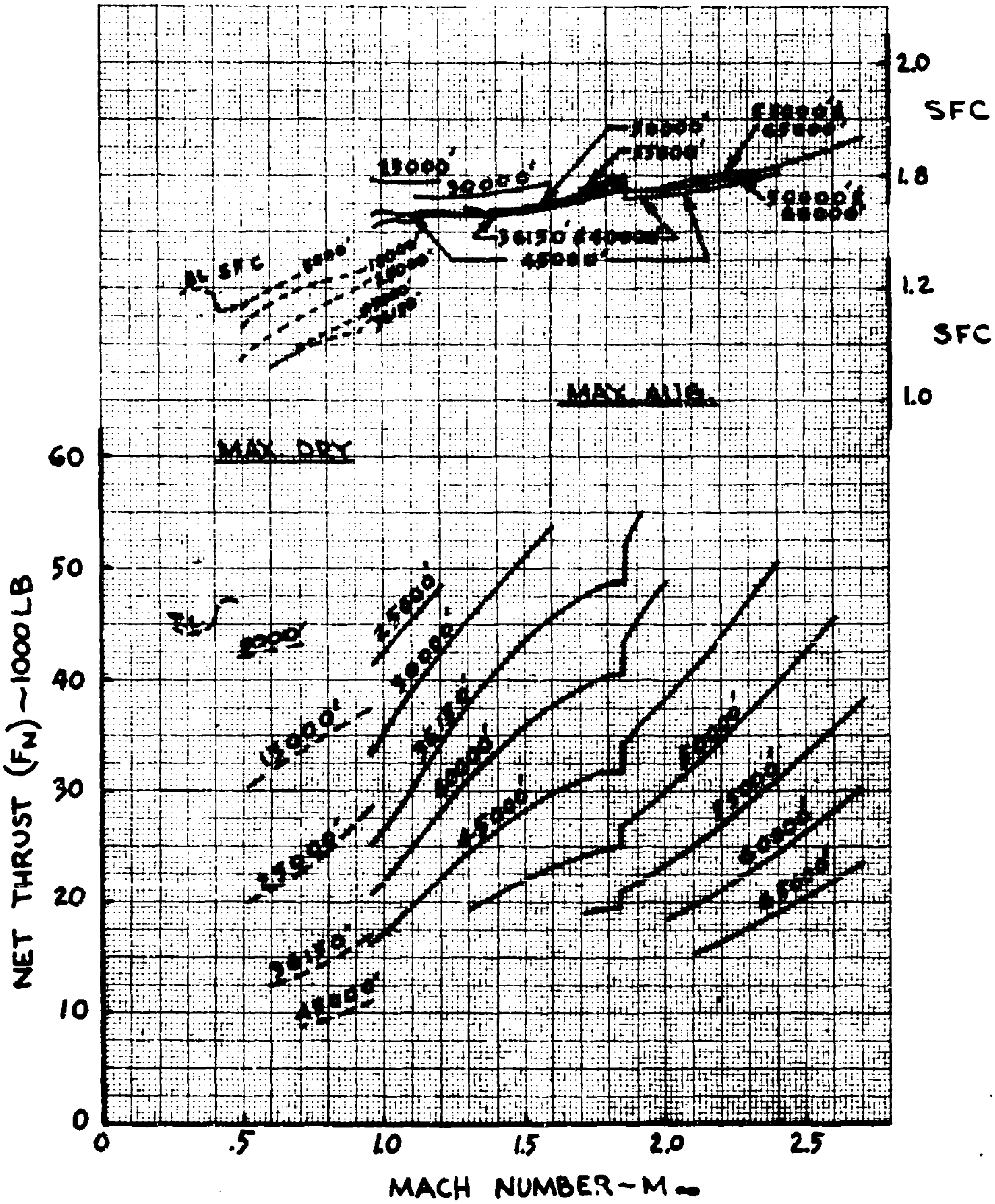


*Figure 4. Climb and Acceleration Net Thrust and SFC, Standard Day*

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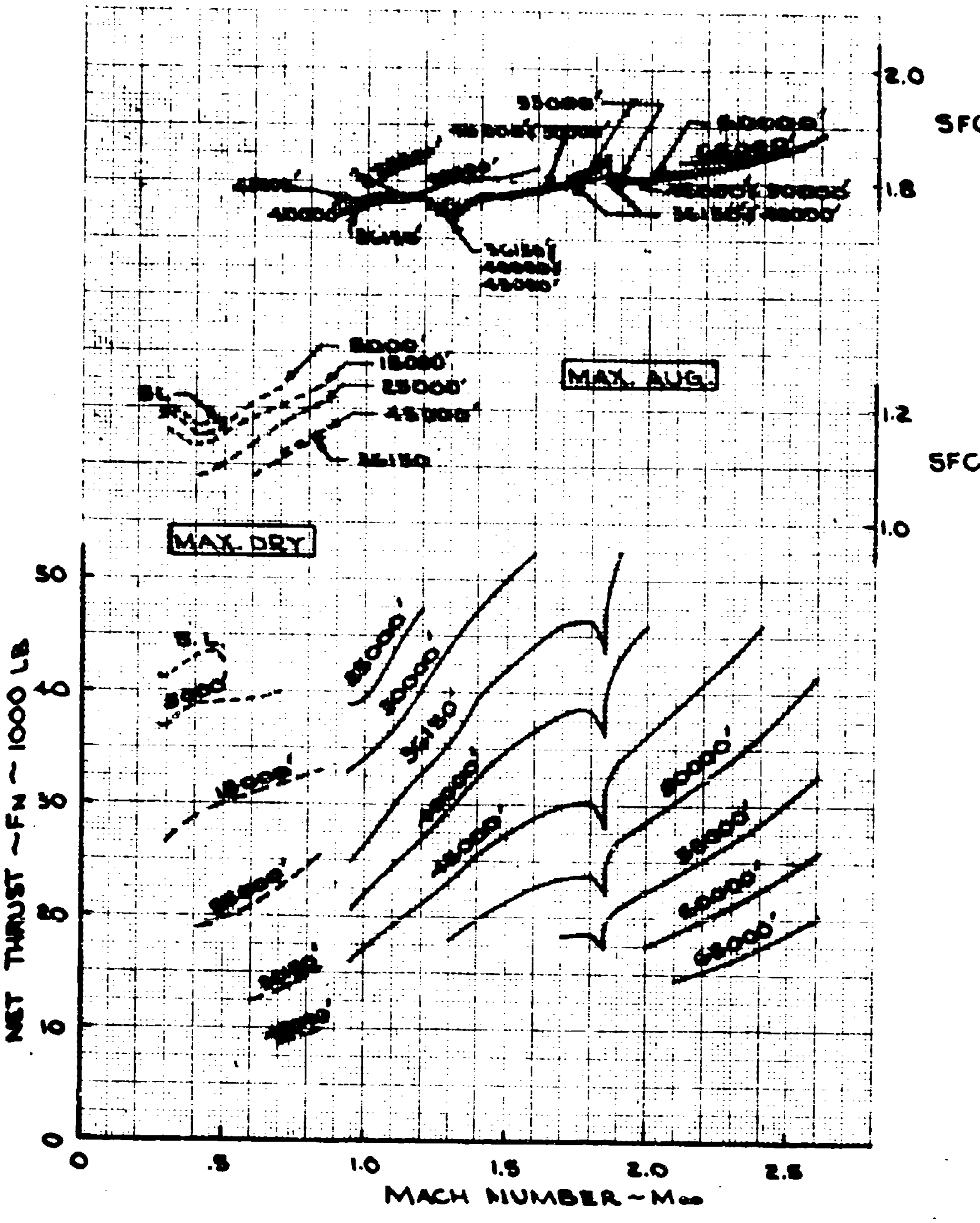


*Figure 5. Climb and Acceleration Net Thrust and SFC, Standard Day + 10° C*

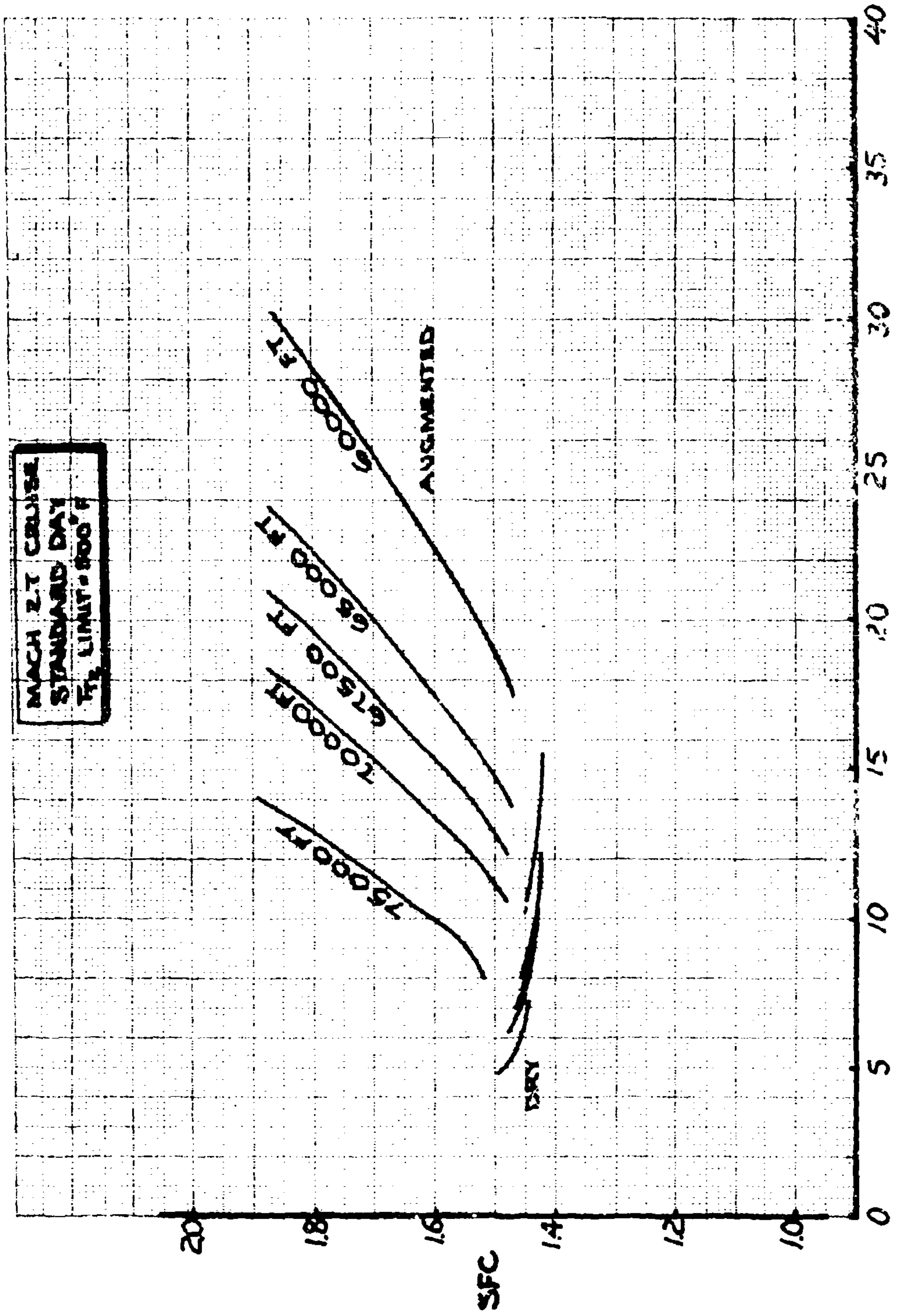


*Figure 6. Cruise Net Thrust and SFC, Standard Day*

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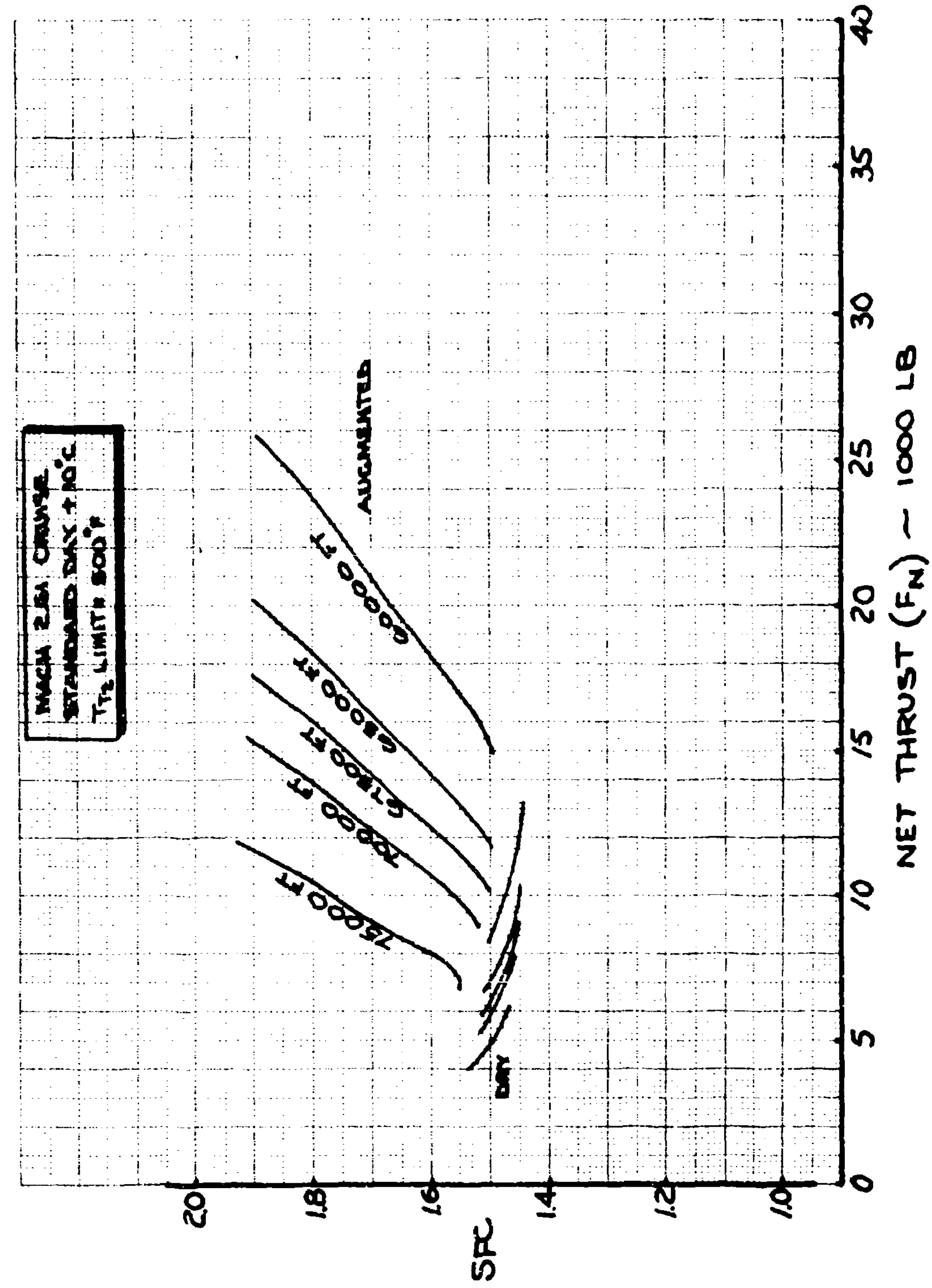


*Figure 7. Cruise Net Thrust and SFC, Standard Day + 10°C*

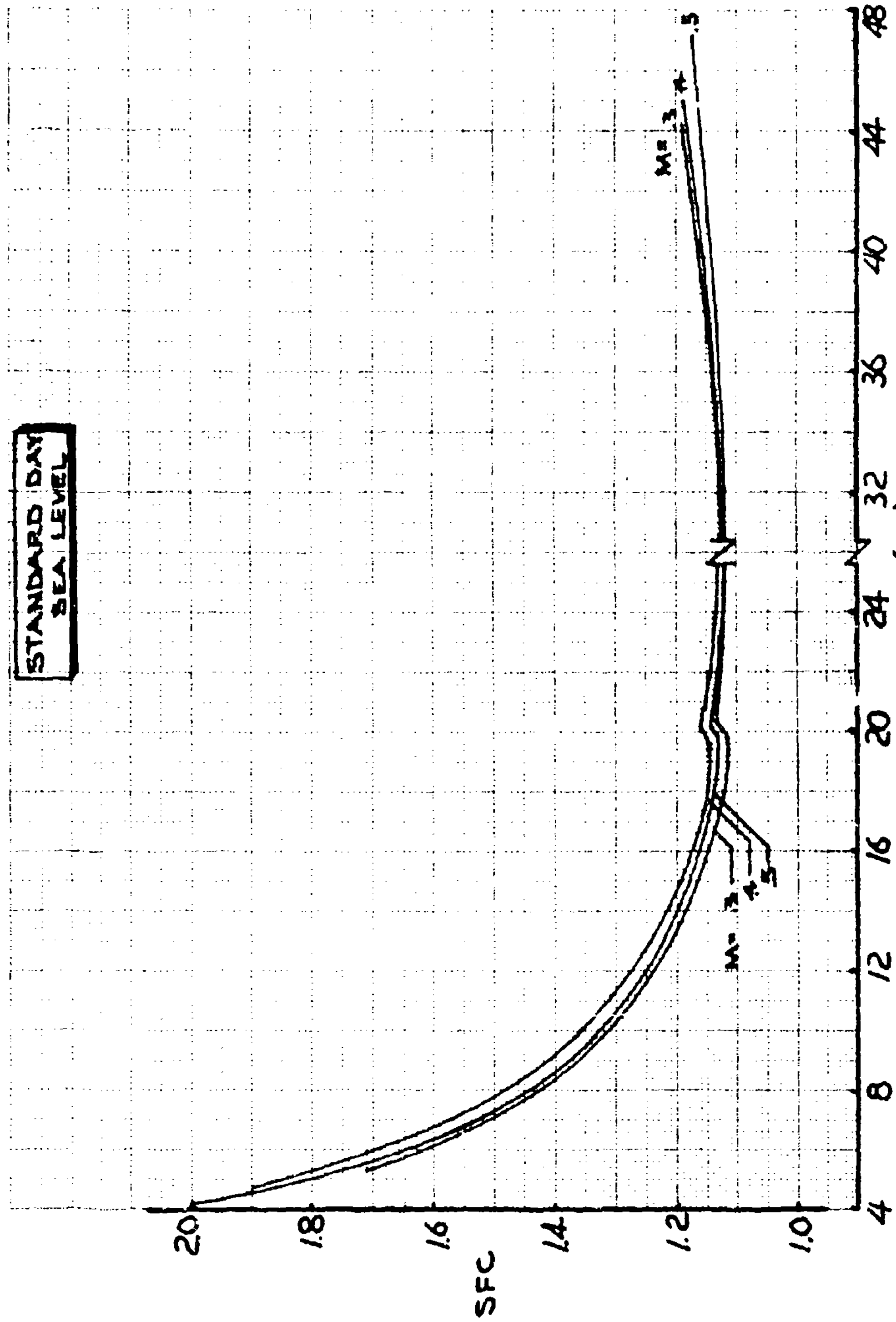


*Figure 8. Subsonic Net Thrust and SFC, Sea Level*

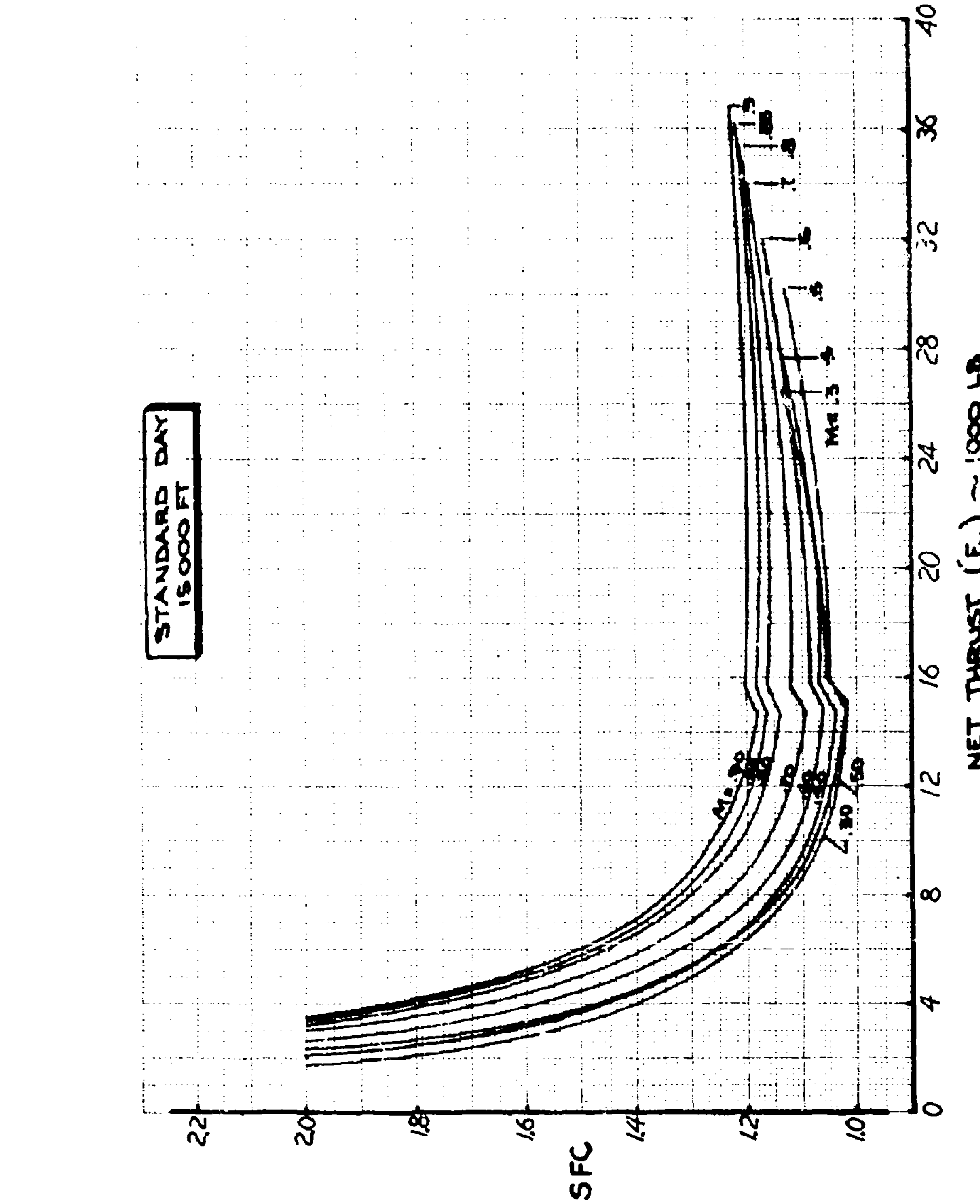


*Figure 9. Subsonic Net Thrust and SFC, 15,000 Feet*

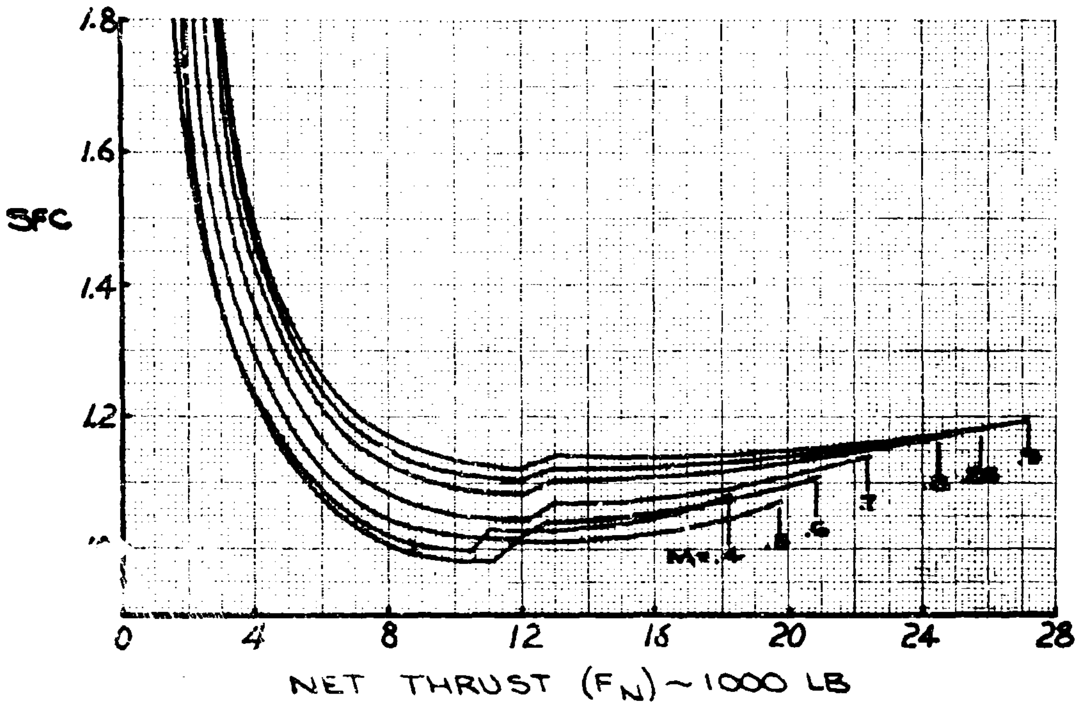


*Figure 10. Subsonic Net Thrust and SFC, 25,000 Feet*

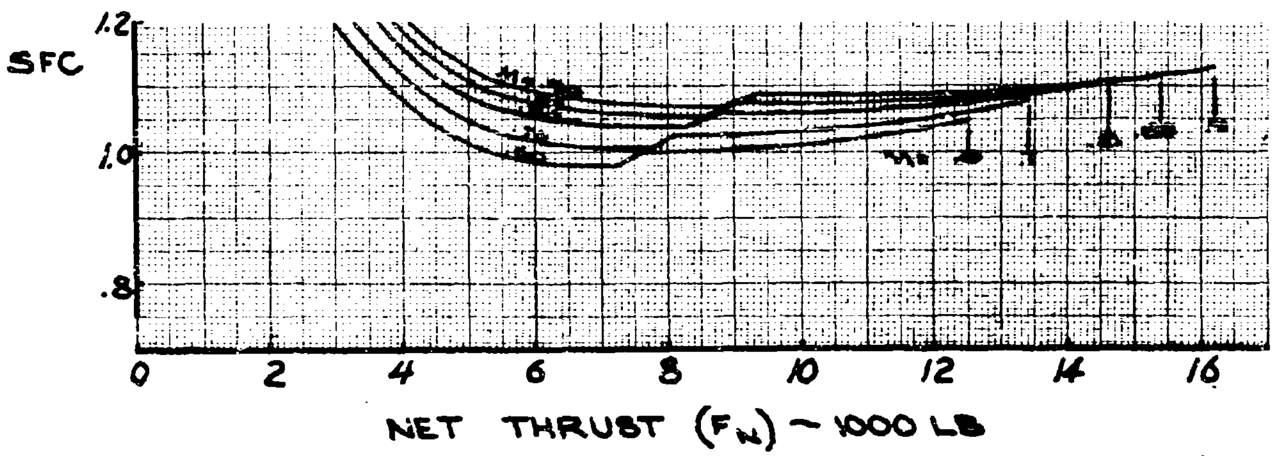


*Figure 11. Subsonic Net Thrust and SFC, 36,150 Feet*

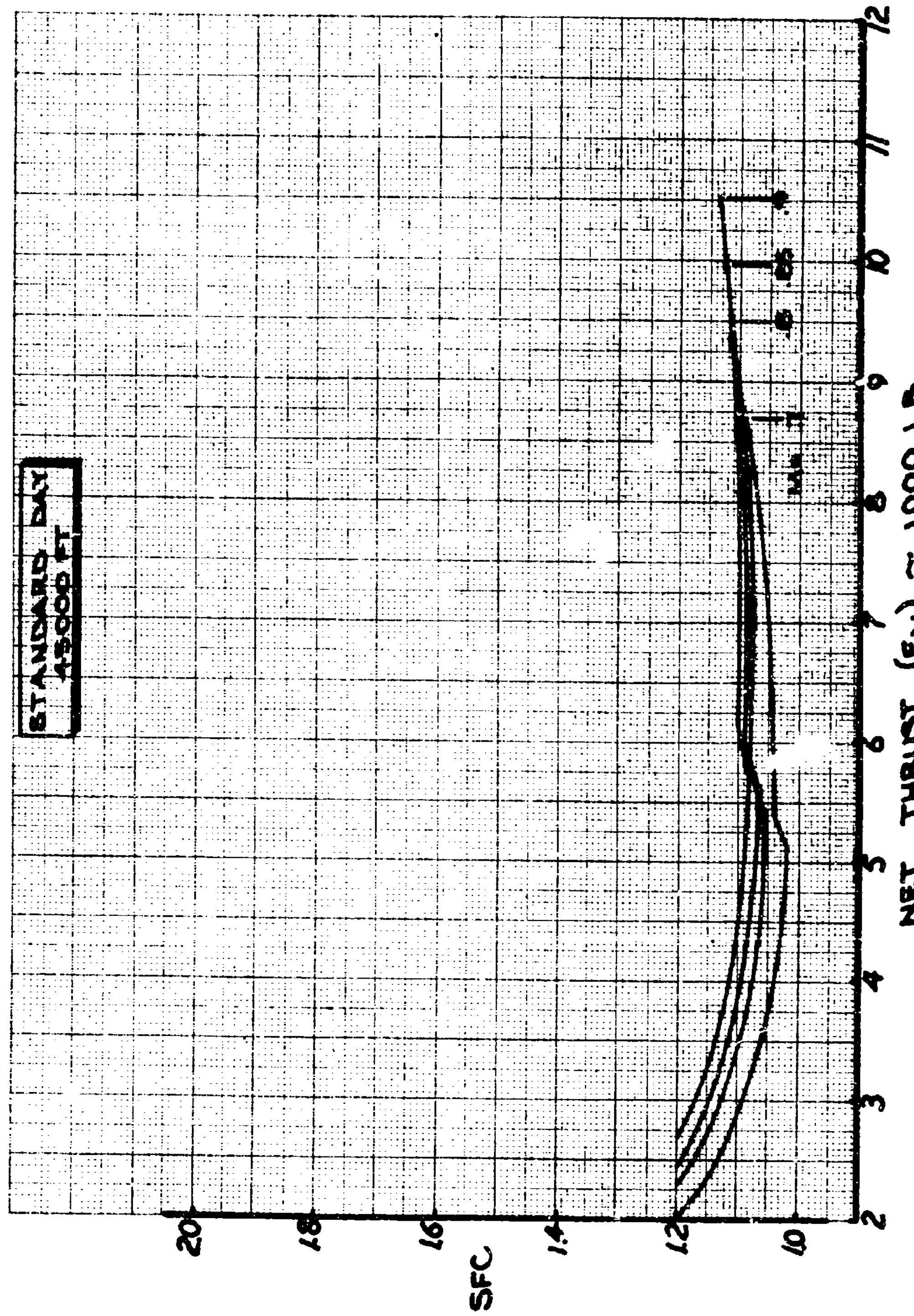


*Figure 12. Subsonic Net Thrust and SFC, 45,000 Feet*

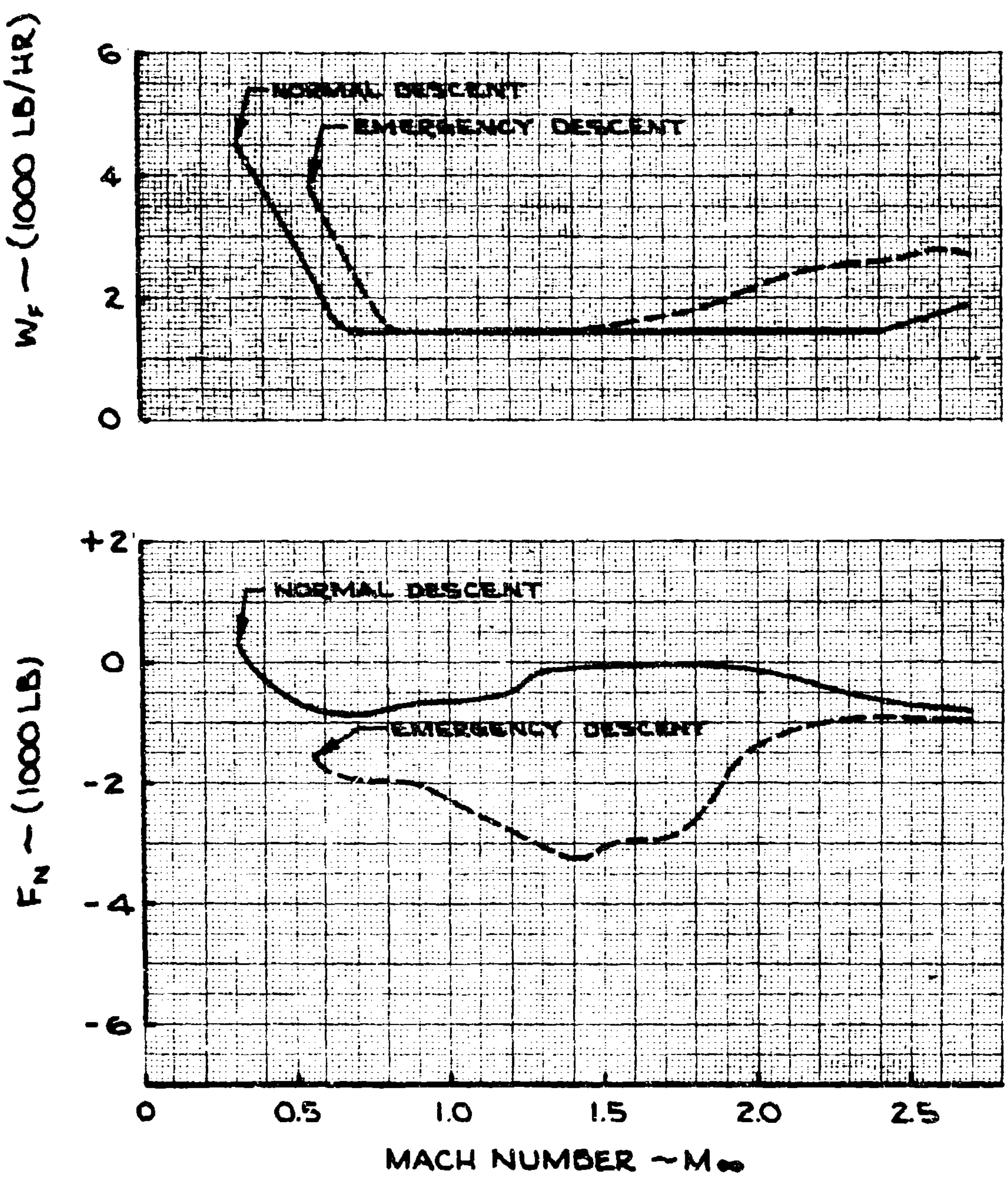


*Figure 13. Normal and Emergency Descent Thrust and Fuel Flow, Standard Day*

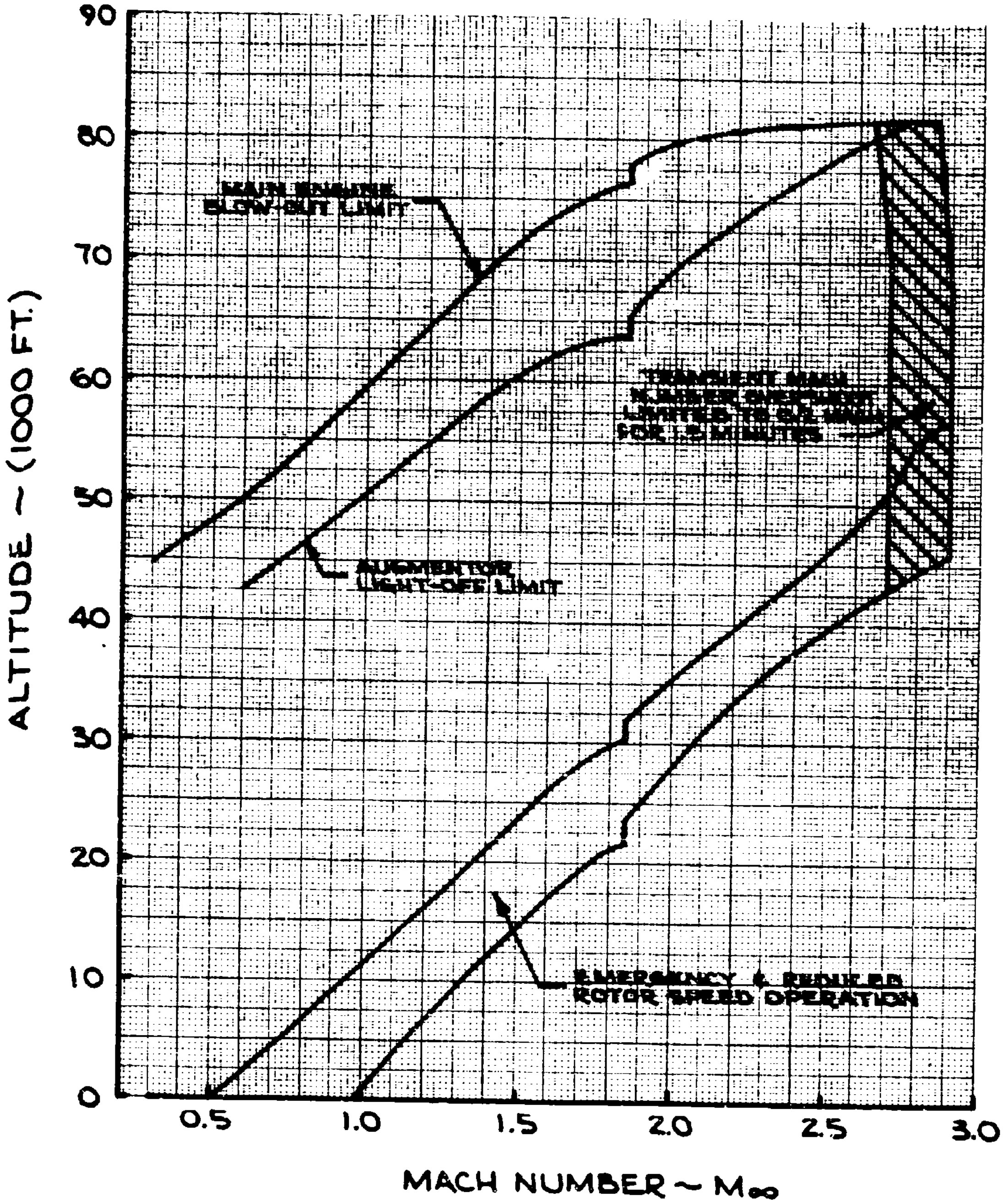


*Figure 14. Engine Operating Envelope, Standard Day*

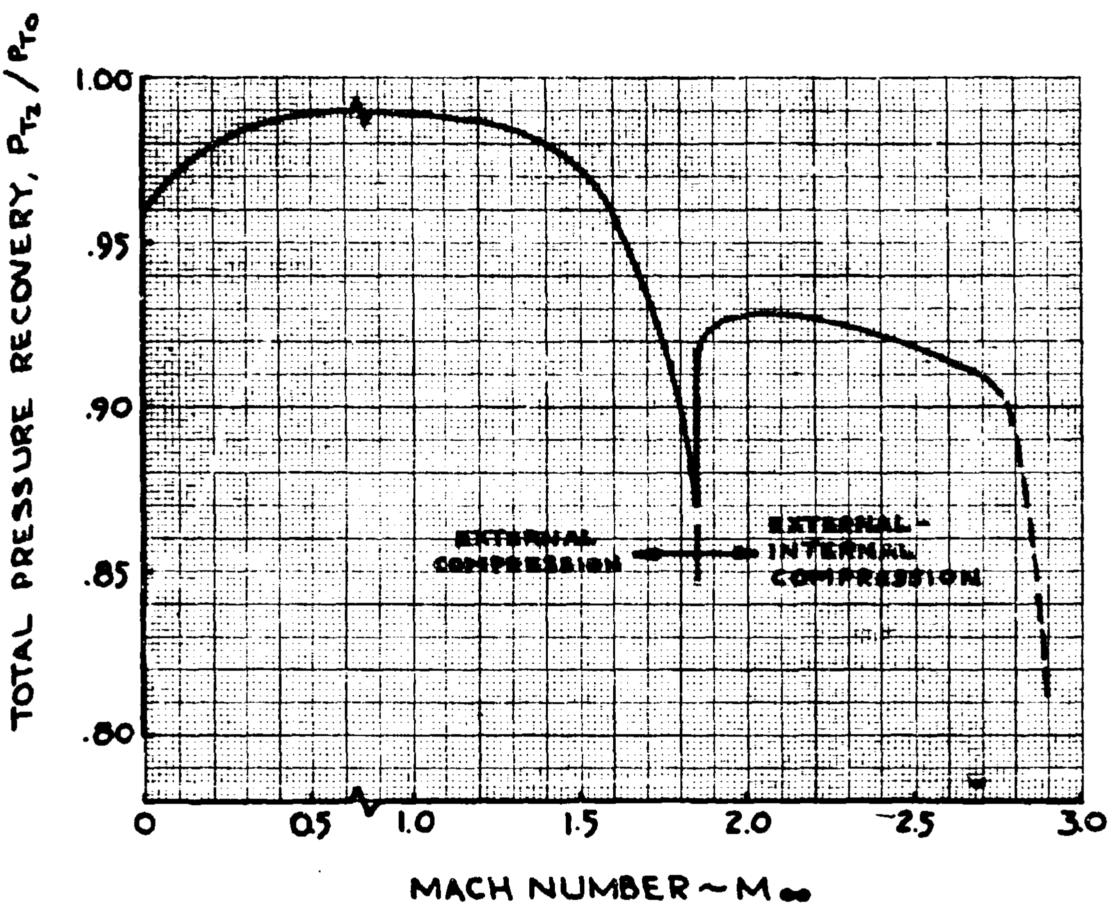


*Figure 15. Inlet Total Pressure Recovery*

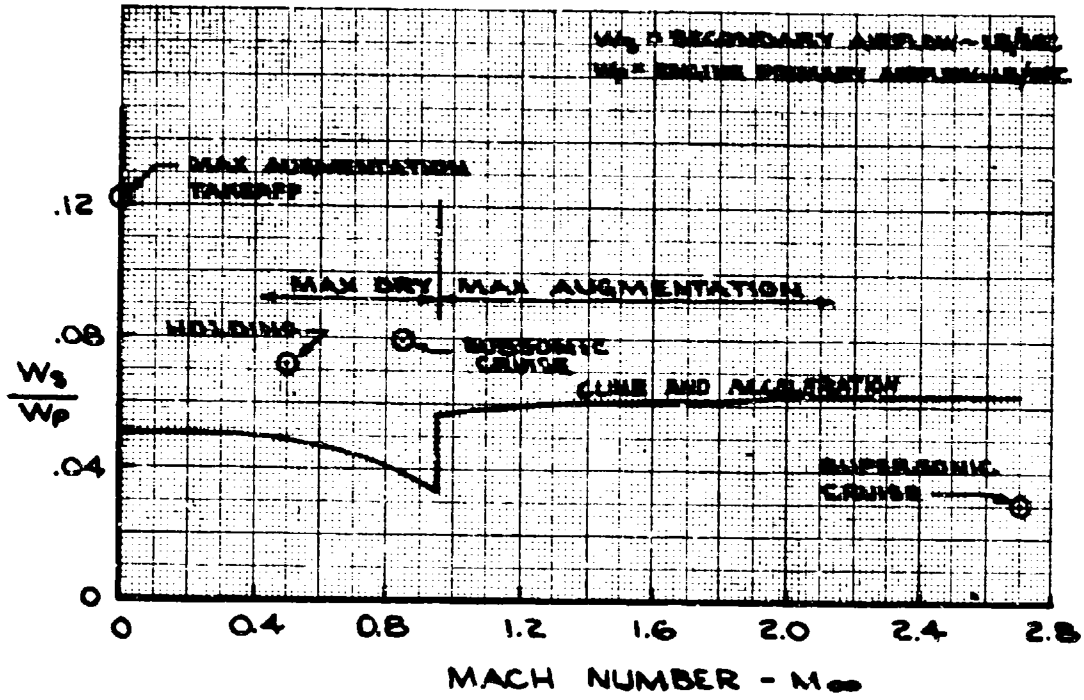


*Figure 16. Nozzle Secondary Airflow Schedule*

*Table II. Average Horsepower Extractions*

| Airplane Operating Condition | Horsepower Extraction Per Engine |
|---|---|
| Takeoff | 450 |
| Climb and acceleration | 450 |
| Supersonic cruise | 450 |
| Holding at Mach 0.4, 15,000 ft | 450 |
| Cruise to alternate at Mach 0.8, 36,150 ft | 450 |
| Descent $M < 1.2$ | 400 |
| $M \geq 1.2$ | 500 |

3.1.1.1.2 Inlet Drag Characteristics. The inlet drag for all flight operating conditions shall be calculated by analytical methods. The inlet drag calculation method is based on summation of spillage, bypass and boundary layer bleed drag increments. Fig. 18 is an inlet schematic identifying terms used in calculating inlet drag, additive drag and spillage drag.

3.1.1.1.2.1 Engine Demand. Typical mission engine airflow demands in terms of freestream inlet capture area shown in Fig. 20 are based on engine airflow including nozzle secondary airflow and using the inlet total pressure recovery schedule shown in Fig. 15 and nozzle secondary flow schedule shown in Fig. 16 and mission design placards shown in Fig. 17. The engine airflow demand in square feet is calculated by the following equation.

$$A_E = \frac{W_2 \sqrt{\theta_{T_2}}}{\delta_2} \left(\frac{P_{T_2}}{P_{T_o}}\right) f(M_o) .0108 \left(\frac{R}{\gamma g}\right)^{1/2}$$

Where $f(M_o) = \frac{1}{M}\left[1 + \left(\frac{\gamma - 1}{2}\right) M^2\right]^{\frac{\gamma+1}{2(\gamma-1)}}$

and $\frac{W_2 \sqrt{\theta_{T_2}}}{\delta_2}$ = Engine corrected flow

$\left(\frac{P_{T_2}}{P_{T_o}}\right)$ = Inlet Recovery

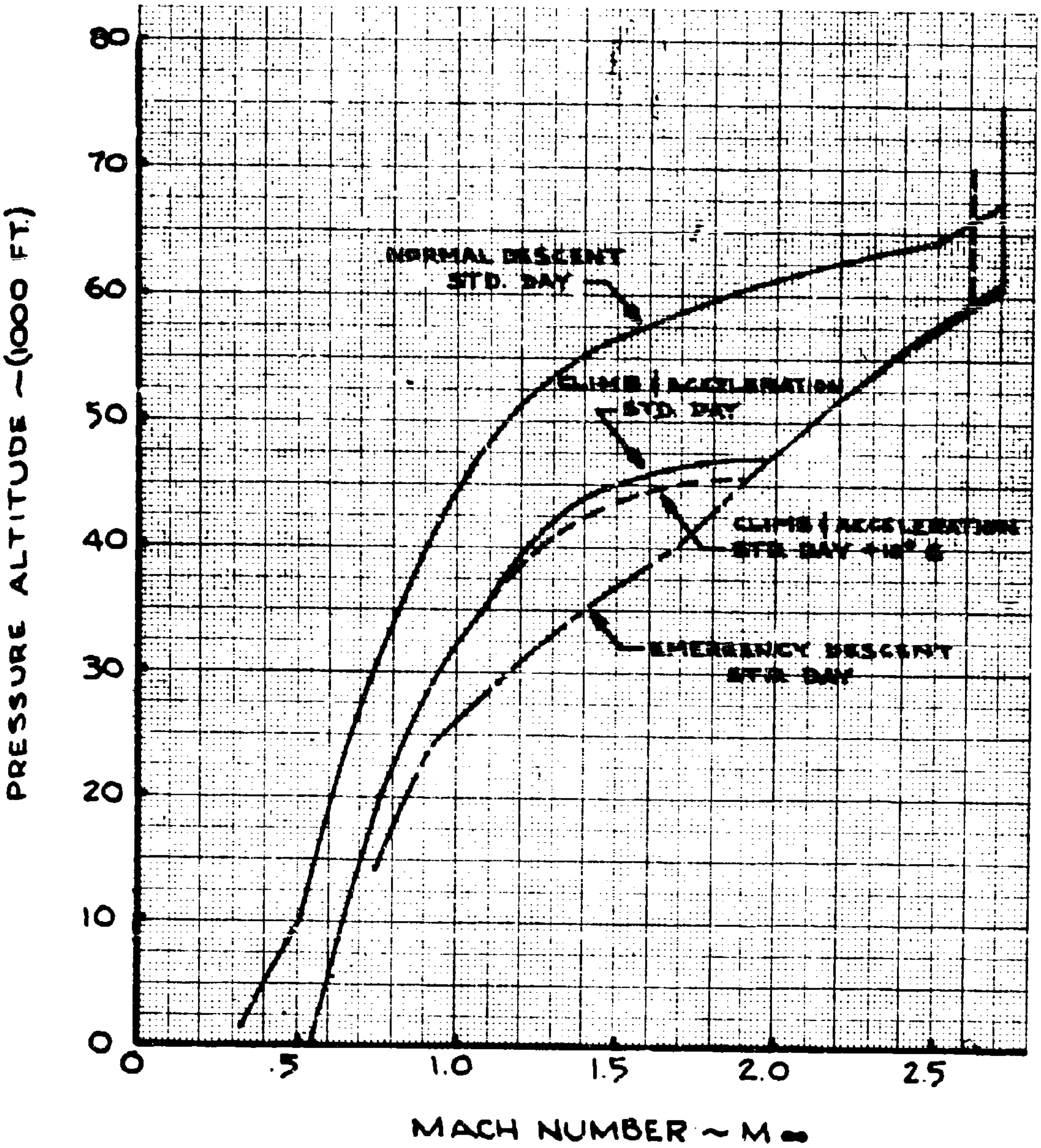


*Figure 17. B-2707 Design Mission Placards*

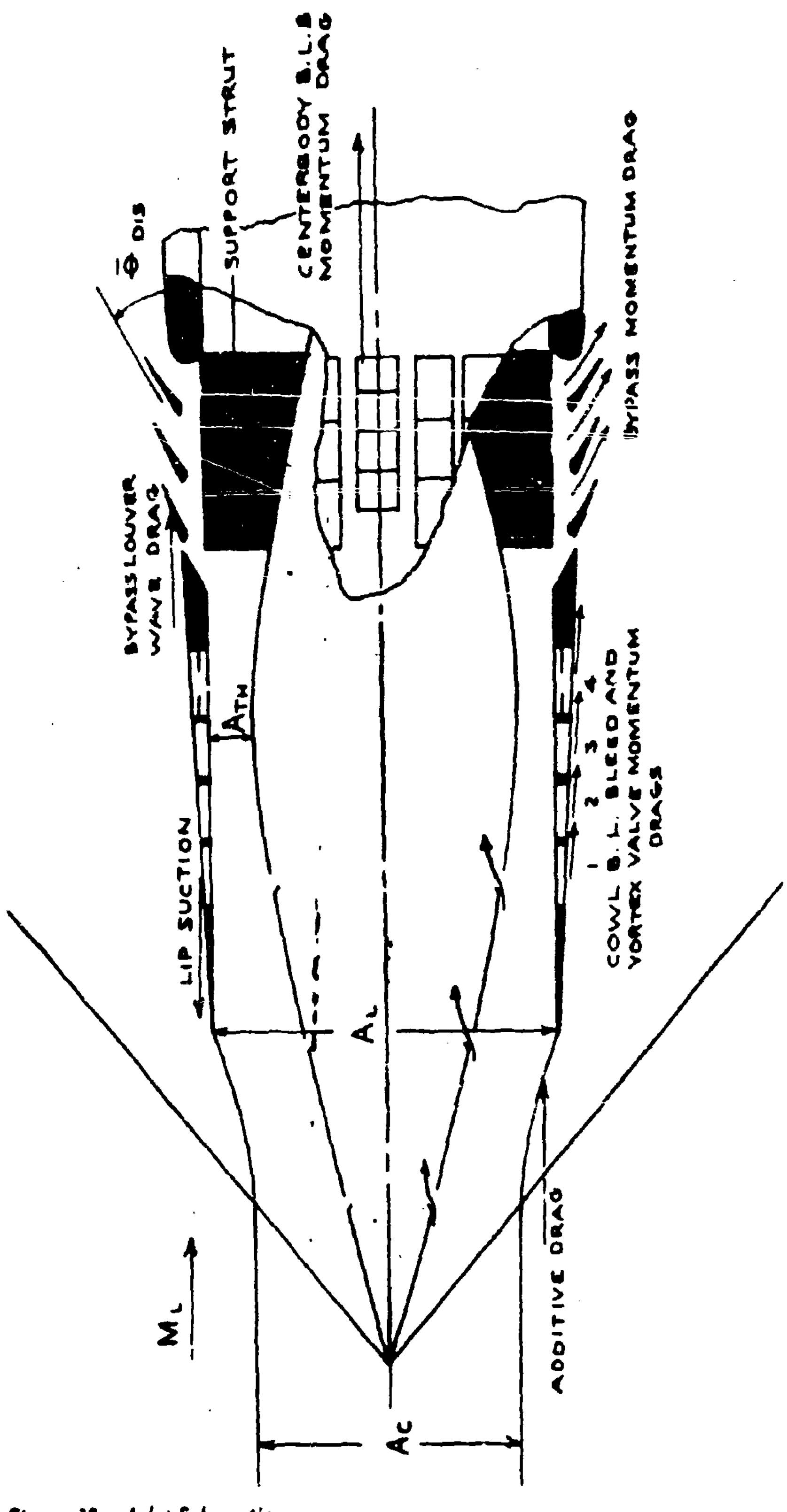


*Figure 18. Inlet Schematic*

R = Universal gas constant

g = Gravitational acceleration

M = Freestream Mach number

$\gamma$ = Ratio of specific heats

3.1.1.1.2.2 Inlet Supply-Engine Demand. The inlet supply capture area ratio and engine demand area ratio curves are shown for the following four engine operating conditions:

Fig. 21a. Climb and Acceleration, Standard Day

Fig. 21b. Climb and Acceleration, Standard Day +10°C

Fig. 21c. Normal Descent, Standard Day

Fig. 21d. Emergency Descent, Standard Day

The engine demand curves shown include nozzle secondary air, and are corrected to local inlet flow conditions based on the local to freestream Mach number relationship shown in Fig. 19.

3.1.1.1.2.2.1 Part Power Engine Demand, Standard Day. The engine demand capture area ratios for selected part power conditions are shown in Fig. 22. At part throttle operation minimum excess air drag shall be achieved by control of the inlet throat Mach number.

3.1.1.1.2.3 Inlet Installed Drag Coefficient. The composite curves of inlet installed drag coefficients shown in Figs. 23 through 26 are based on freestream dynamic pressure and inlet lip frontal area of 21.23 sq ft for all calculations.

3.1.1.1.2.3.1 Climb and Acceleration, Standard Day. A composite curve of inlet installed drag coefficients for climb and acceleration is shown in Fig. 23.

3.1.1.1.2.3.2 Climb and Acceleration, Standard Day +10°C. A composite curve of inlet installed drag coefficients is shown in Fig 24 for climb and acceleration.

3.1.1.1.2.3.3 Normal Descent, Standard Day. A composite curve of inlet installed drag coefficients is shown in Fig. 25 for normal descent.

3.1.1.1.2.3.4 Emergency Descent, Standard Day. A composite curve of inlet installed drag coefficients is shown in Fig. 26 for emergency descent.

3.1.1.1.2.3.5 Part Power, Standard Day. The inlet installed drag coefficient increments for part throttle engine demand are shown in Fig. 27 for selected part power conditions. The total installed inlet drag

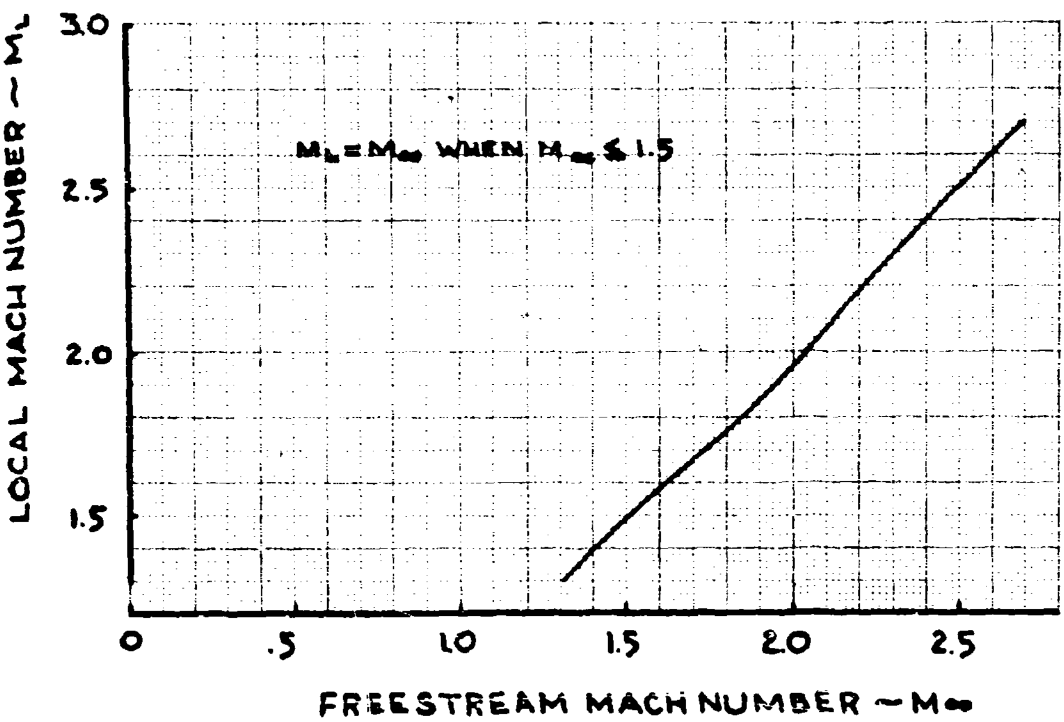


*Figure 19. Local Mach Number Versus Freestream Mach Number*

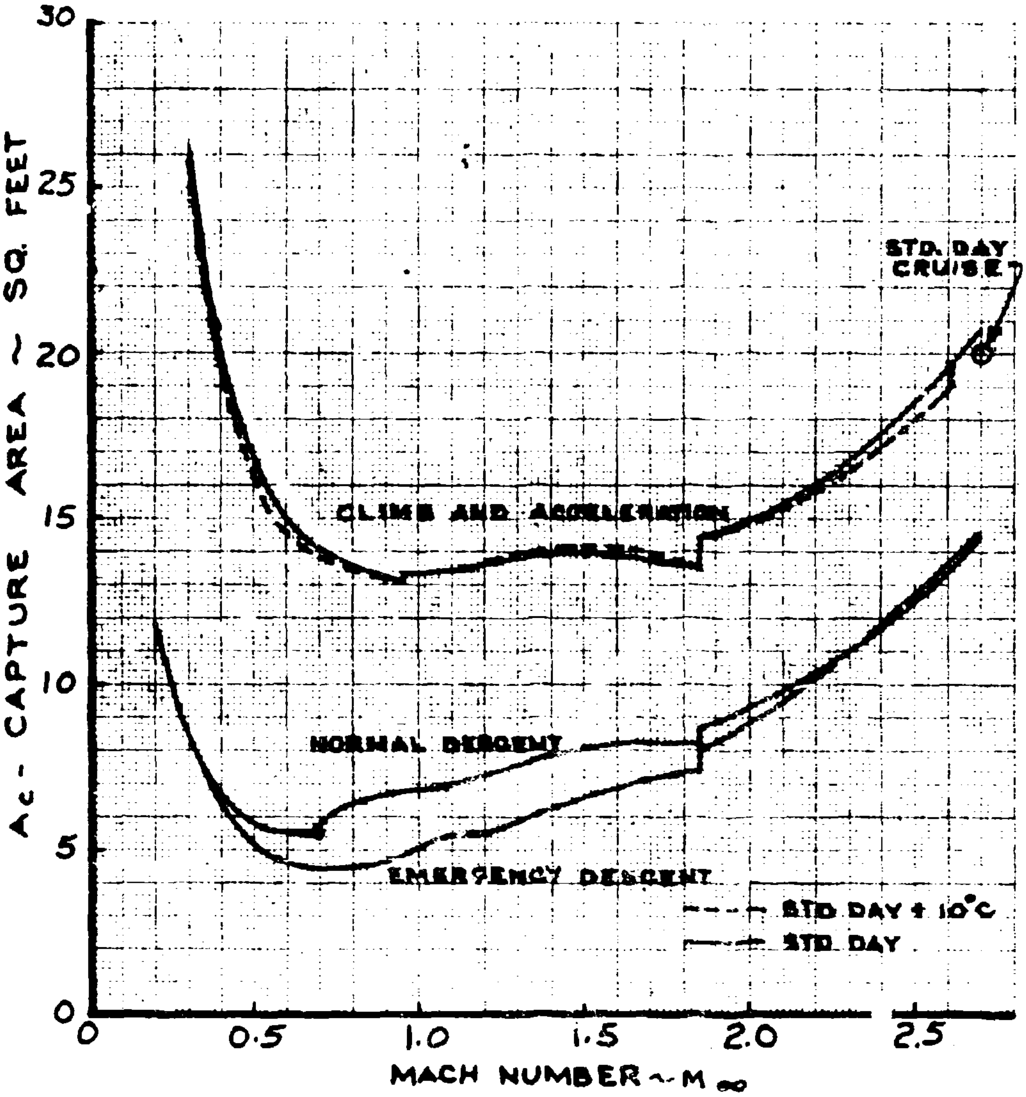


*Figure 20. F...stream Capture Area, Design Mission Placard*

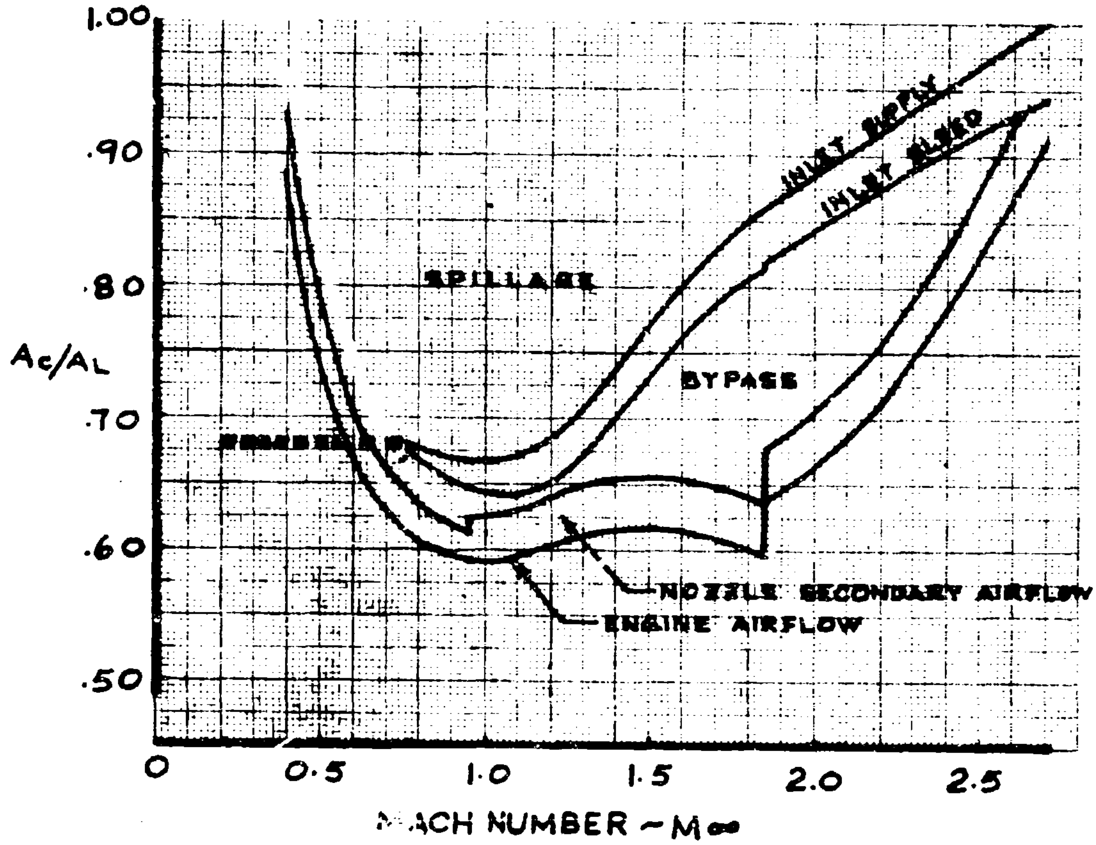


*Figure 21a. Inlet Supply/Engine Demand Area Ration, Climb and Acceleration, Standard Day*

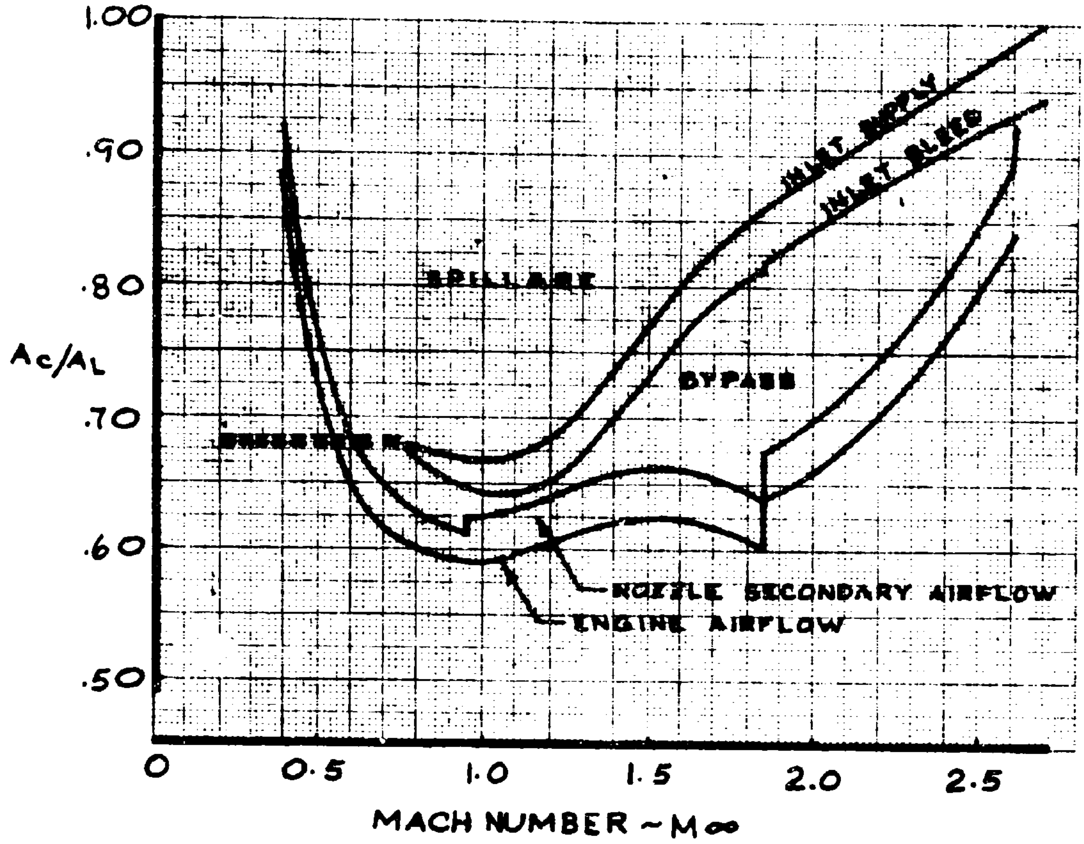


*Figure 21b. Inlet Supply/Engine Demand Area Ratio, Climb and Acceleration, Standard Day + 10° C*

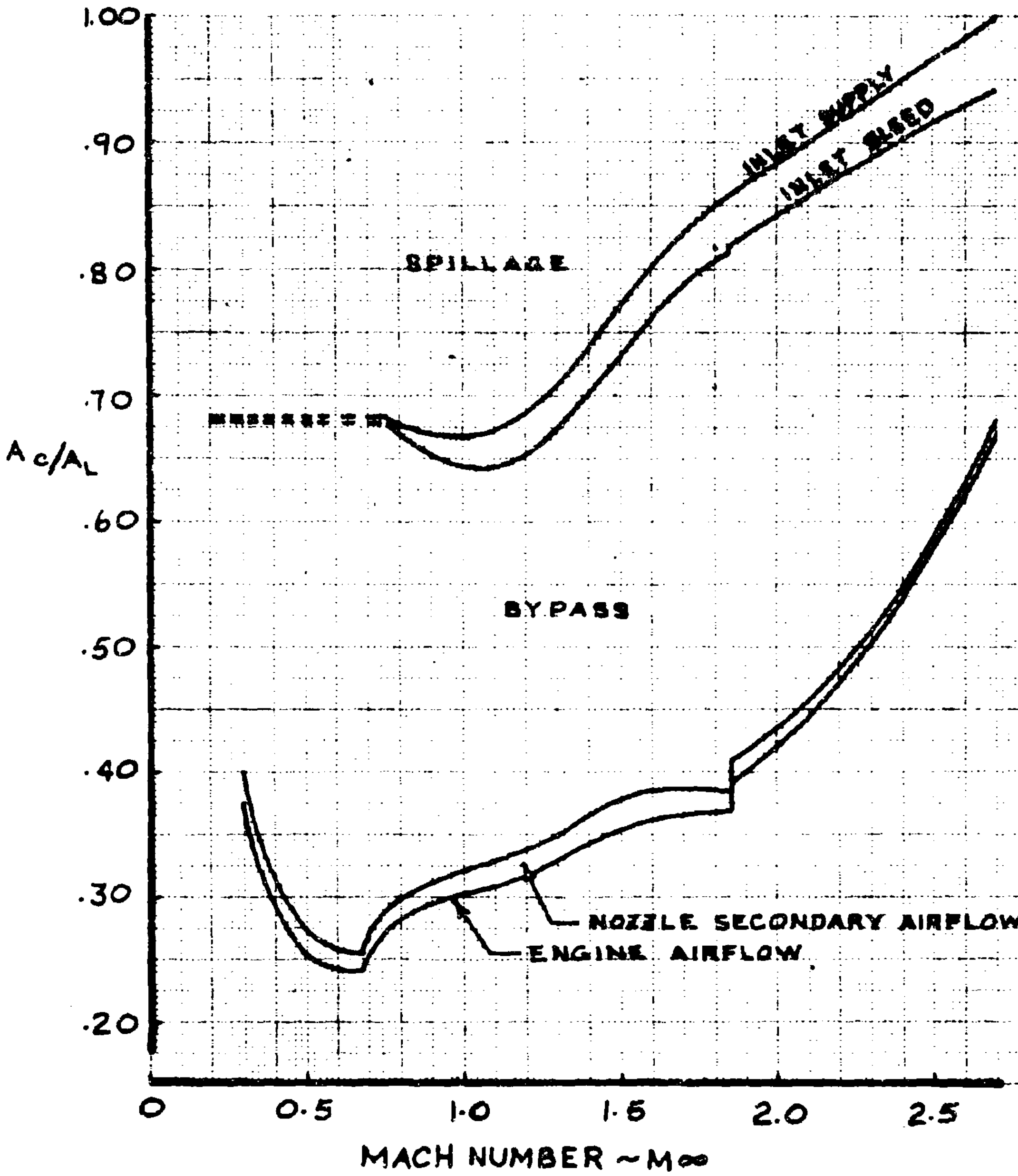


*Figure 21c. Inlet Supply/Engine Demand Area Ratio, Normal Descent, Standard Day*

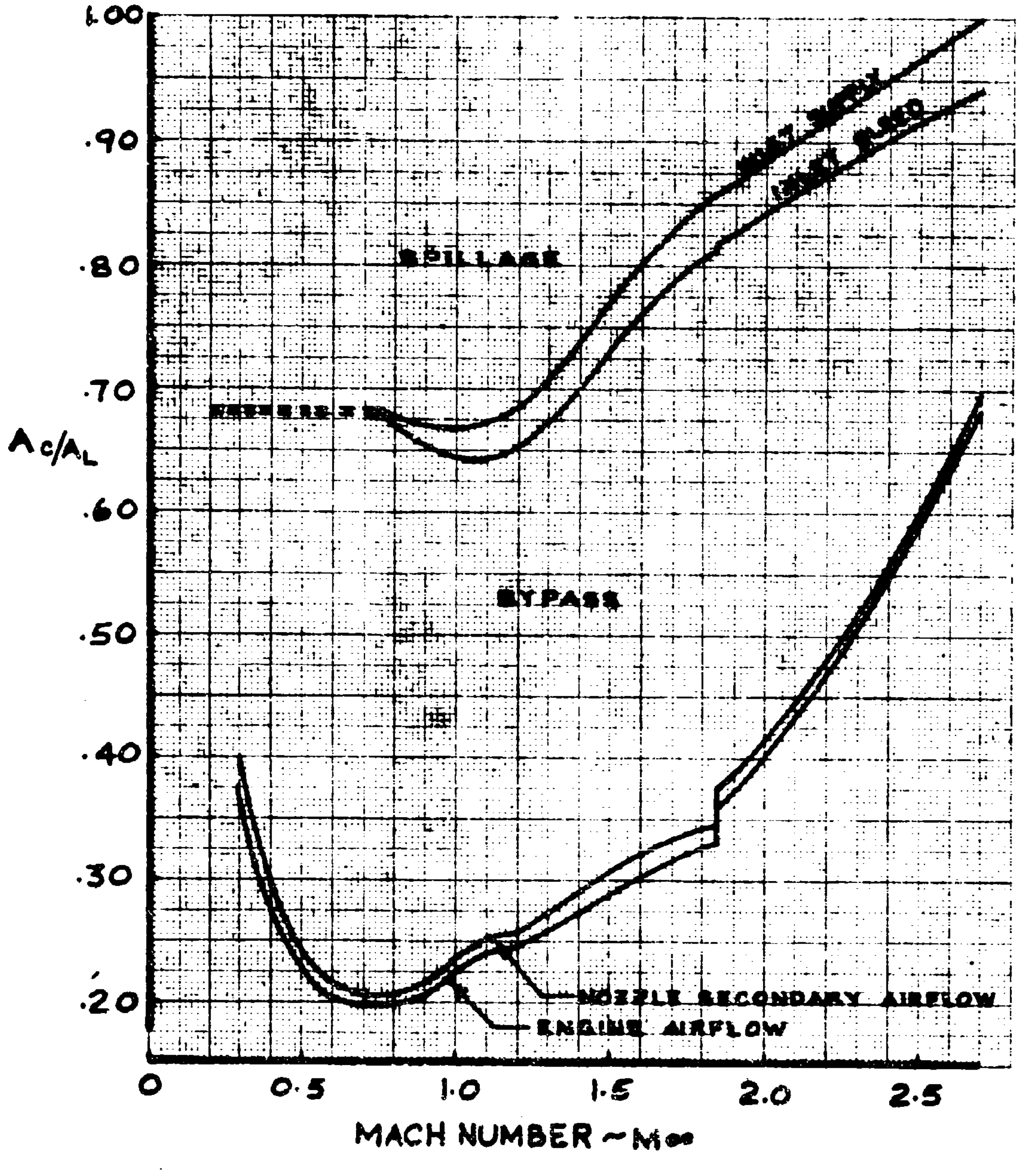


*Figure 21d. Inlet Supply/Engine Demand Area Ratio Emergency Descent, Standard Day*

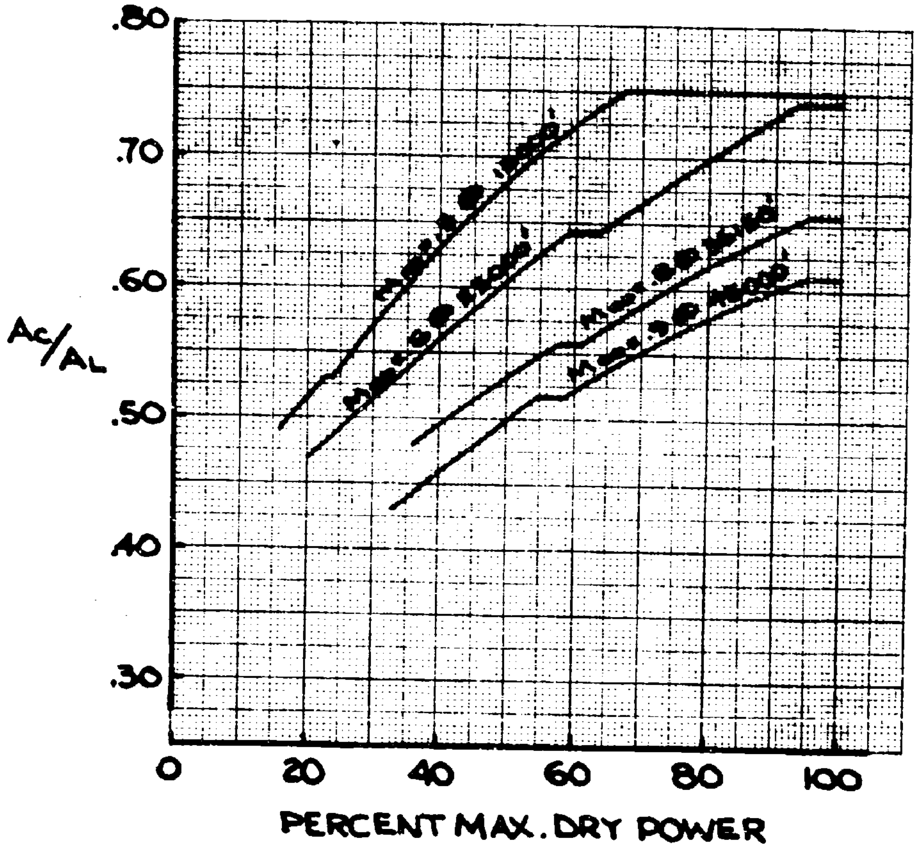


*Figure 22. Part Power Engine Demand Area Ratio, Standard Day*

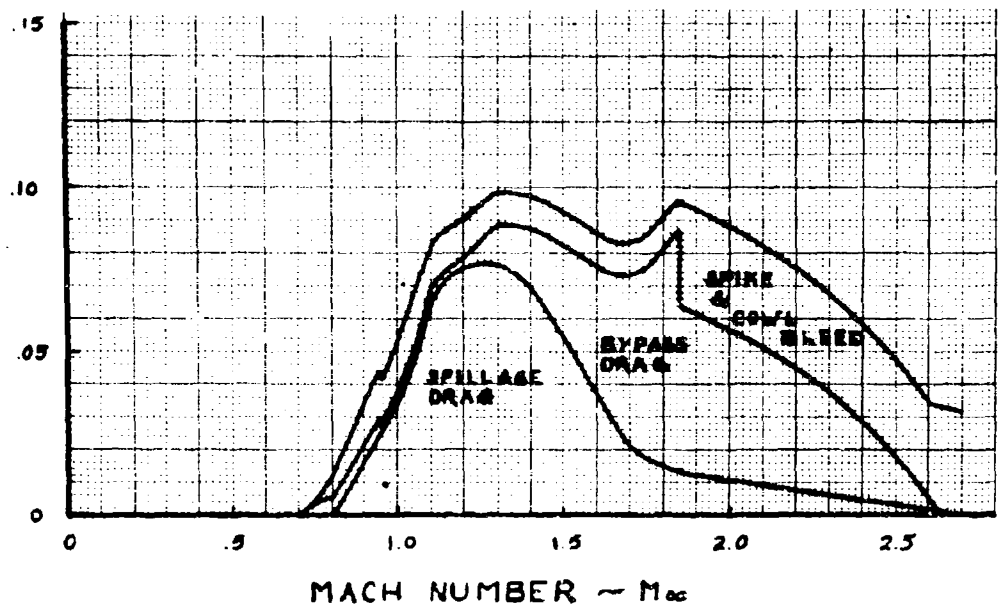


*Figure 23. Inlet Installed Drag Coefficient, Climb and Acceleration, Standard Day*

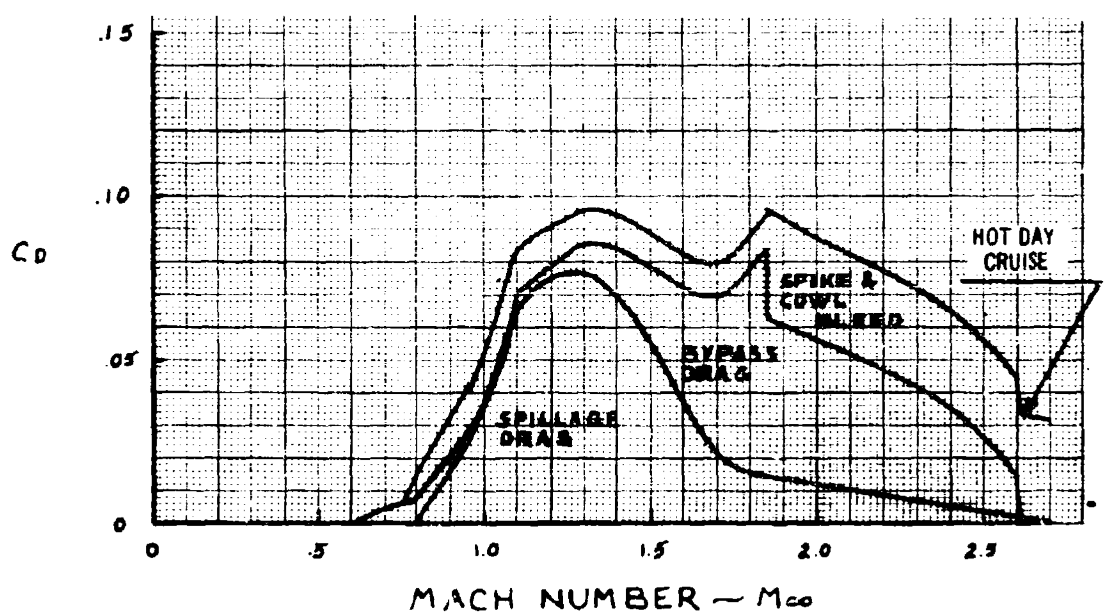


*Figure 24. Inlet Installed Drag Coefficient, Climb and Acceleration, Standard Day + 10° C*

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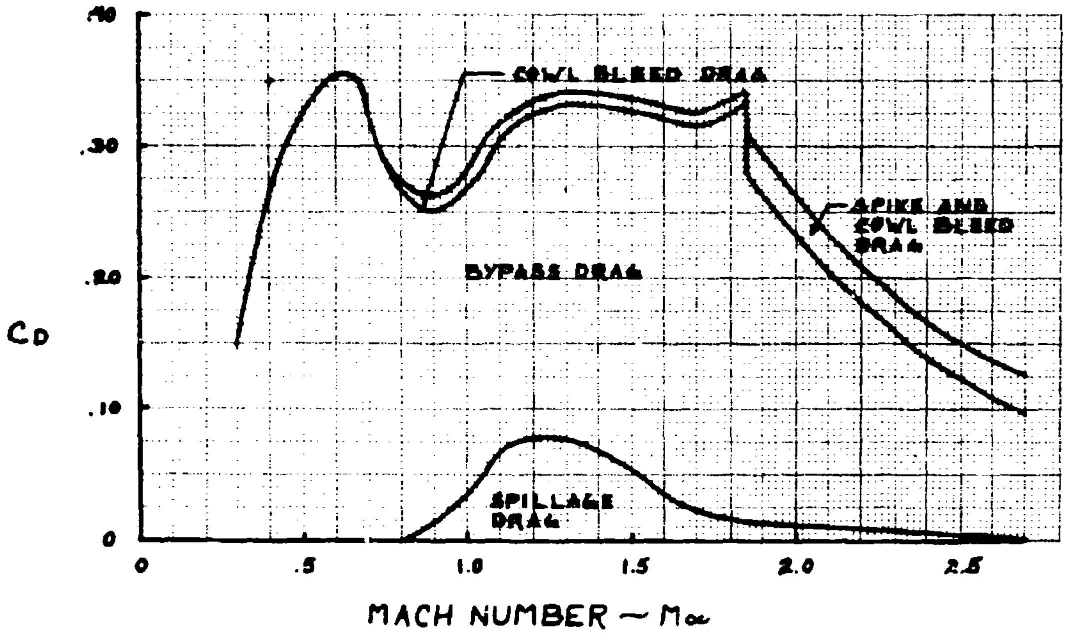



*Figure 25. Inlet Installed Drag Coefficient, Normal Descent, Standard Day*

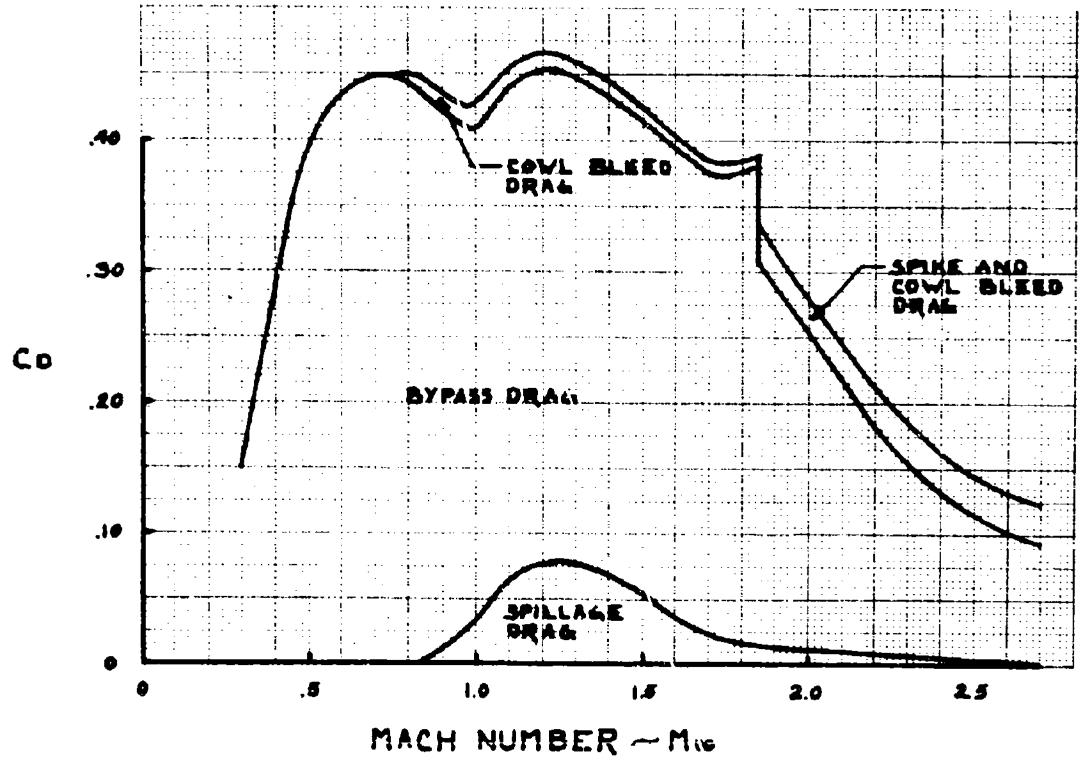



*Figure 26. Inlet Installed Drag Coefficient, Emergency Descent, Standard Day*

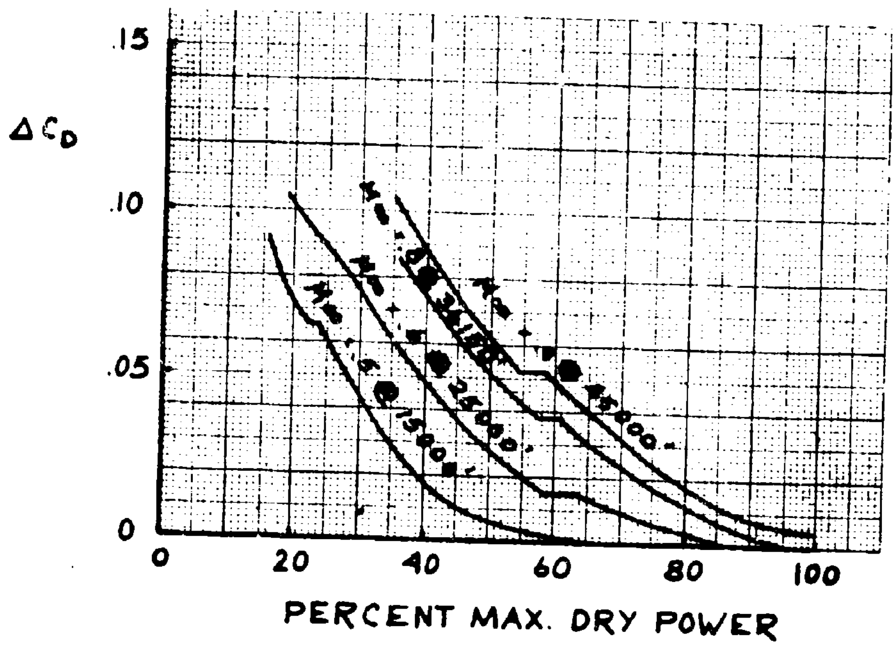



*Figure 27. Part Power Excess Air Drag Coefficient – Standard Day*

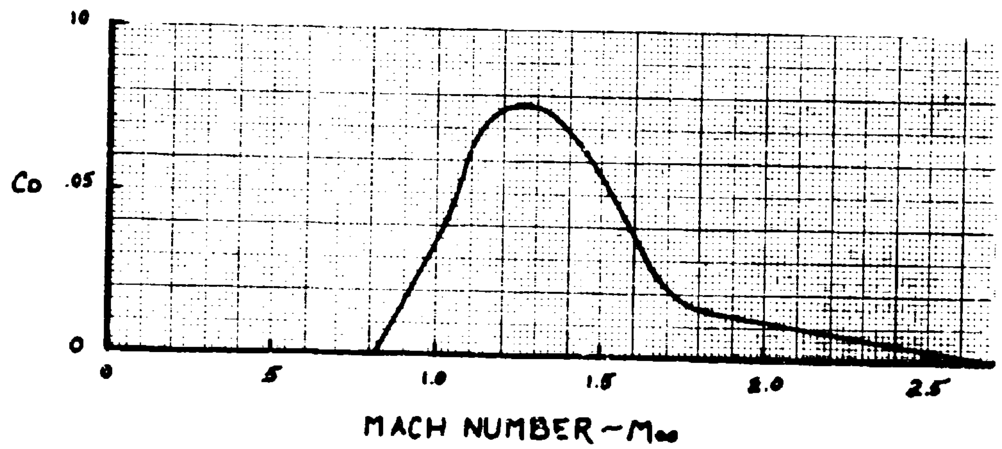



*Figure 28. Inlet Spillage Drag Coefficient*

coefficient for part power operation shall be the sum of the part power drag coefficient increments and the drag coefficients shown in Fig. 23.

3.1.1.1.2.4 Inlet Spillage Drag Coefficient. The inlet spillage drag coefficient is shown in Fig. 28. Below Mach 1.3, inlet spillage drag has been determined by inlet drag tests. For Mach numbers above 1.3, spillage drag was calculated by taking the difference between the theoretical additive drag and lip suction force.

3.1.1.1.2.4.1 Inlet Additive Drag Coefficient. Above Mach 1.3, the additive drag coefficient was calculated by the following equation:

$$C_{D_{ADD}} = C_{D_{\text{Conical Flow}}} + C_{P_{\text{Stagnation}}} \left[ \frac{M_c}{M_L}_{\text{Conical Flow}} - \frac{M_c}{M_L} \right]$$

$$\text{where } C_{P_{\text{Stagnation}}} = \frac{\left(\frac{6M_L^2}{5}\right)^{3.5} \left(\frac{6}{7M_L^2 - 1}\right)^{-1}}{\frac{7}{10} \quad M_L^2}$$

The conical flow additive drag coefficient ($C_D$) Conical Flow and Mass Flow ratio $(M_c/M_L)_{\text{Conical Flow}}$ are computed by the methods contained in

M.I.T. Technical Report No. 1. The difference between the theoretical conical flow mass flow ratio and the inlet operating mass flow ratio (normal shock spillage) is shown in Fig. 29. The additive drag coefficient for Mach numbers above 1.3 is shown in Fig. 30.

3.1.1.1.2.4.2 Lip Suction Force Coefficient. The lip suction force coefficient is shown in Fig. 31. The lip suction force coefficient above 1.8 was calculated by the method shown in D6-7842. The ratio of lip suction force to additive drag is shown in Fig. 32.

3.1.1.1.2.5 Inlet Boundary Layer Bleed Drag Coefficient. The cowl boundary layer bleed system shall be divided into four plenum chambers, including the vortex valve. The cowl boundary layer bleed drag shall be based on a bleed flow of 3 percent of the engine demand mass flow at supersonic cruise Mach number. This shall include 0.2 percent leakage for drag estimates. The energy level of the leakage air shall be the same as for the boundary layer bleed from the fourth cowl plenum. The centerbody boundary layer bleed drag shall be based on 2.8 percent of the engine demand mass flow at supersonic cruise. This shall include 0.3 percent leakage for drag estimates. The energy level of the centerbody leakage shall be the same as the centerbody boundary layer bleed. The boundary layer bleed drag coefficients are shown in Fig. 33. This

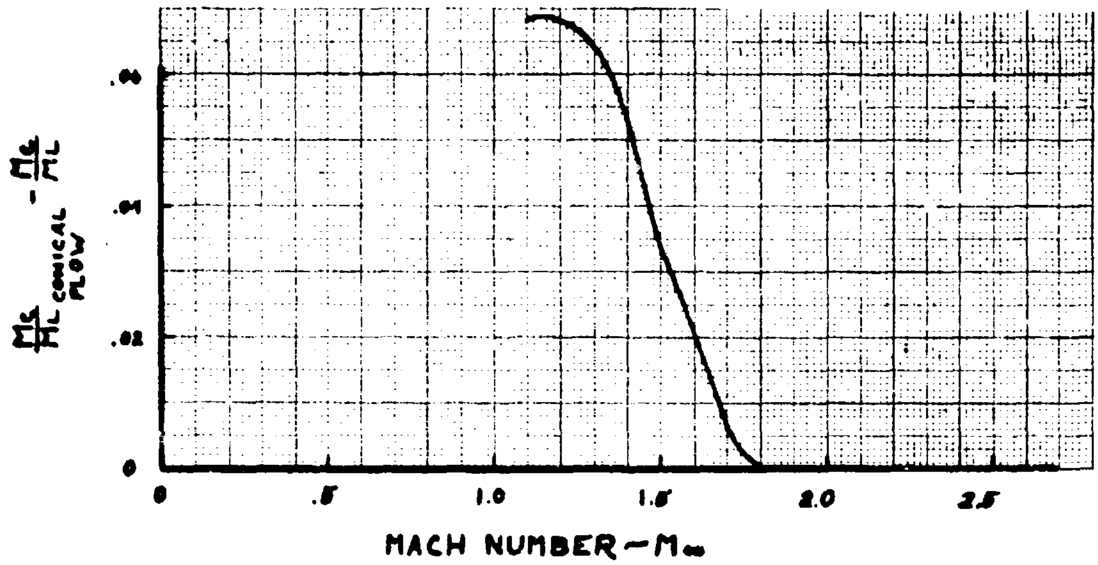



*Figure 29. Normal Shock Spillage*

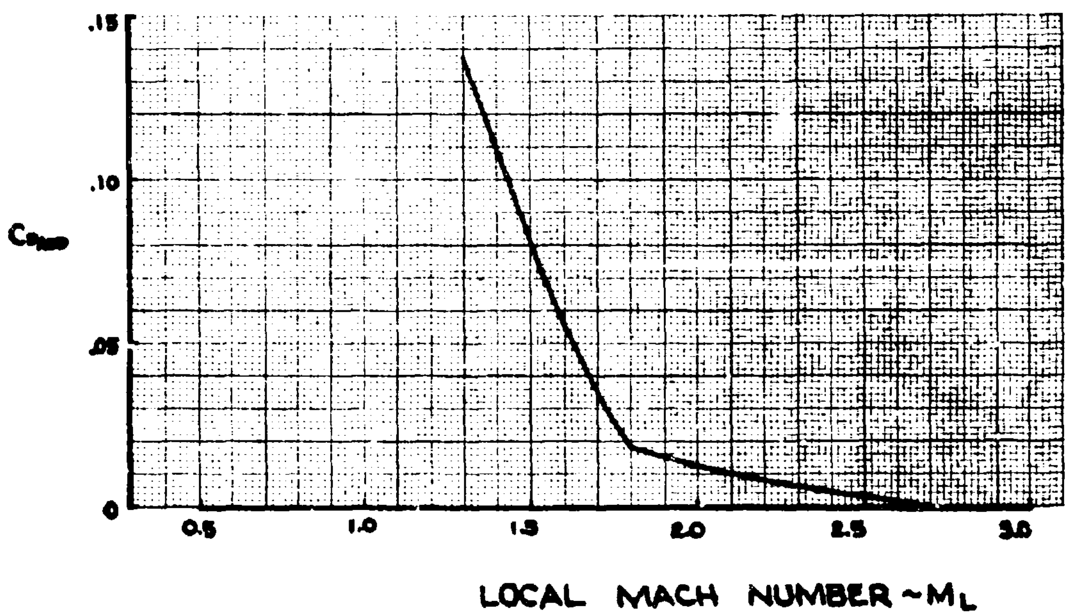



*Figure 30. Additive Drag Coefficient*

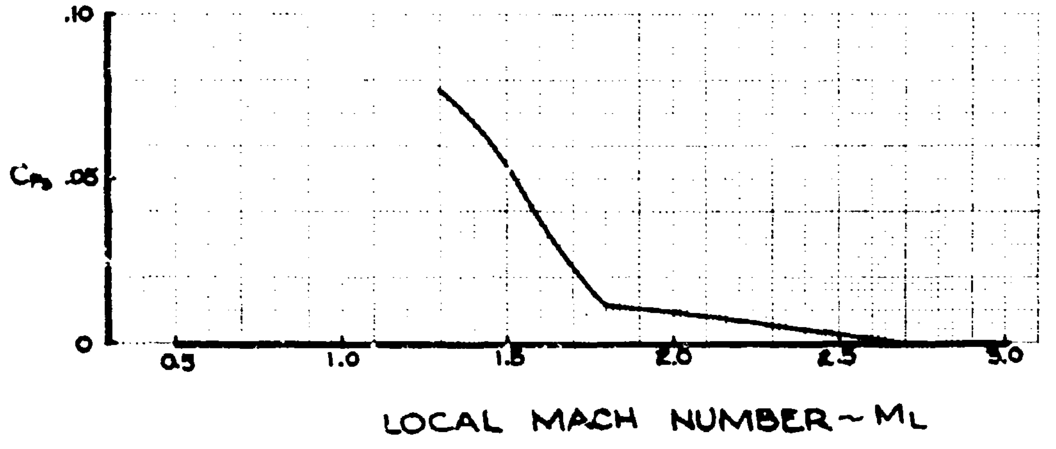



*Figure 31. Lip Suction Force Coefficient*

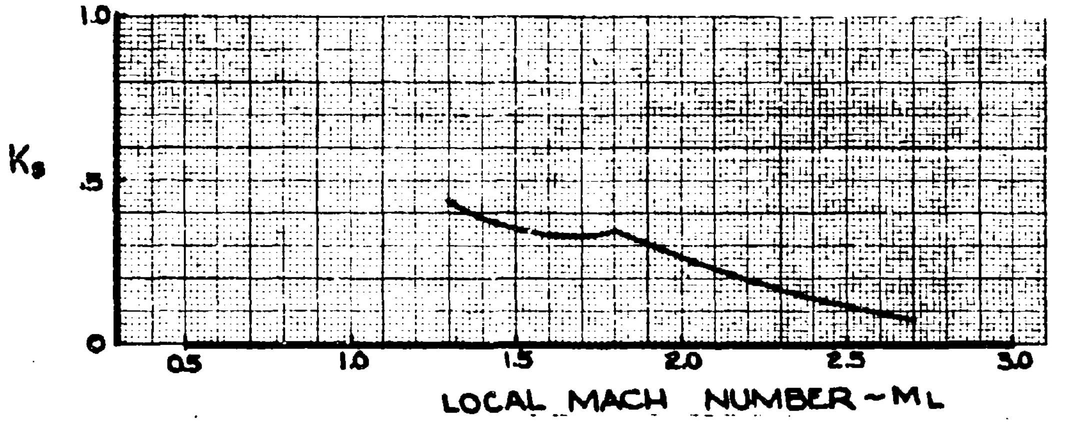



*Figure 32. Lip Suction Ratio, $K_S$*

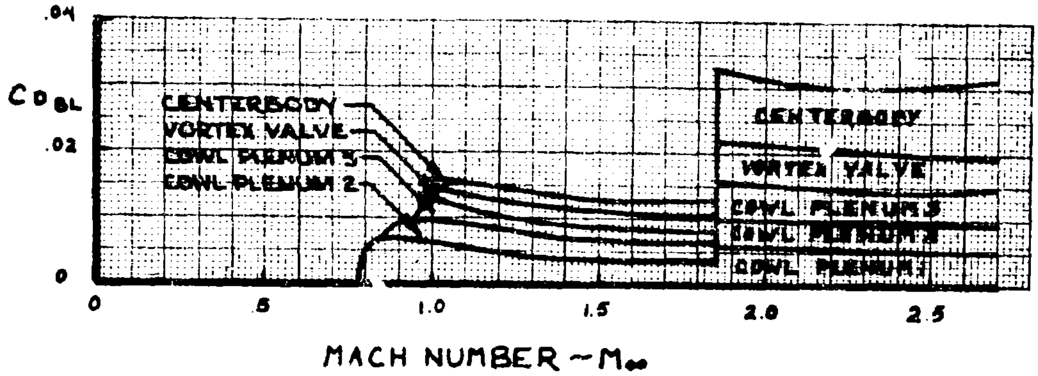



*Figure 33. Inlet Bleed Drag Coefficient*

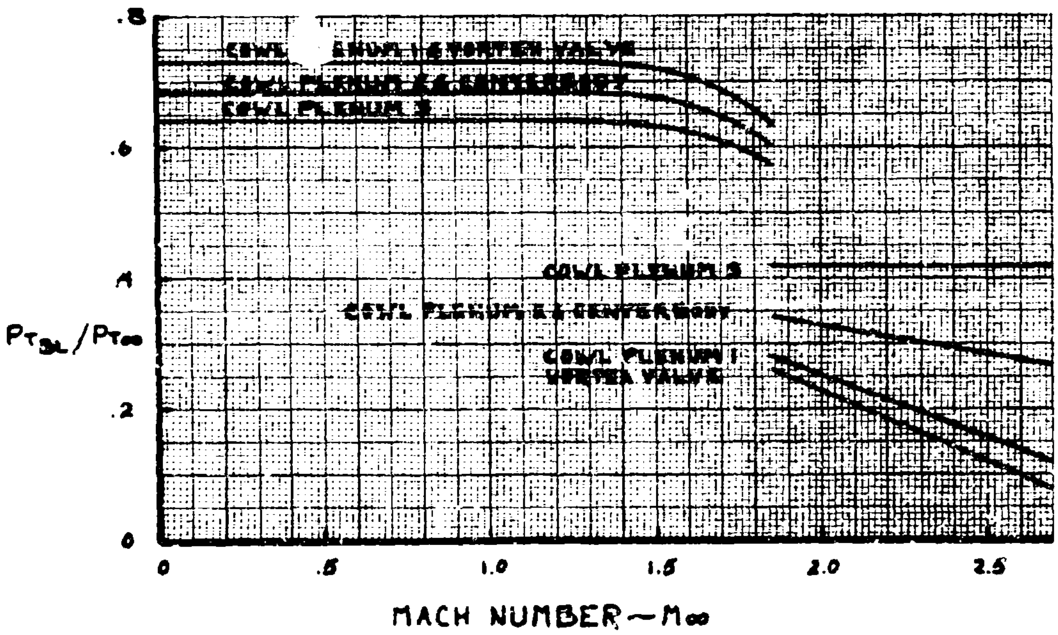



*Figure 34. Inlet Bleed Total Pressure Recovery*

curve is a composite, showing the total boundary layer bleed drag coefficient, and the contribution of each bleed plenum to the total boundary layer bleed drag coefficient. Air-conditioning bleed drag is not shown on this curve.

3.1.1.1.2.5.1 Boundary Layer Bleed Total Pressure Recovery. Boundary layer bleed total pressure recoveries are shown in Fig. 34 for all plenums. A 10-percent total pressure loss is included in the centerbody bleed total pressure recovery to account for ducting from the centerbody plenum to the centerbody bleed discharge.

3.1.1.1.2.5.2 Boundary Layer Bleed Mass Flow Ratio. The boundary layer bleed and air-conditioning bleed mass flow ratios at off-design Mach number are shown in Fig. 35. This curve is a composite, showing the total bleed mass flow ratio, and the contribution of each bleed component to the total bleed mass flow ratio. The bleed mass flow ratios shown in Fig. 35 are based on inlet lip frontal area.

3.1.1.1.2.5.3 Boundary Layer Bleed Exit Thrust Coefficient. The boundary layer bleed exit thrust coefficients for all bleed plenums are shown in Fig. 36. All bleed exits shall be convergent nozzles discharging on 7 deg from the inlet axis. The bleed plenum exit areas are shown on Fig. 36.

3.1.1.1.2.6 Bypass Drag Coefficient. Bypass drag coefficients are shown in Fig. 37. Bypass drag coefficient is the sum of bypass momentum drag coefficient and louver external wave drag.

3.1.1.1.2.6.1 Bypass Mass Flow Ratio. The bypass mass flow ratios are shown in Fig. 38. $^{A}L_{BY}$ is the stream tube area of the bypass flow based on local air density and velocity upstream of the inlet.

3.1.1.1.2.6.2 Louver Wave Drag Coefficient. The estimated external louver wave drags are shown in Fig. 39. The louver ext[illegible] pressure is based on two-dimensional oblique shock relationships (Ref. N.A.C.A. Report No. 1135) with finite aspect ratio pressure relief (Ref. McGraw-Hill, Engineering Supersonic Aerodynamics) when an oblique shock can be sustained ahead of the first louver. For conditions when a normal shock stands ahead of the first louver, the average louver external pressure is determined by using the methods shown in N.A.C.A. Report No.'s 1253 and 1094.

3.1.1.1.2.6.2.1 Louver Setting Angle. The average louver setting angle relative to the cowl external surface is calculated from the following equation:

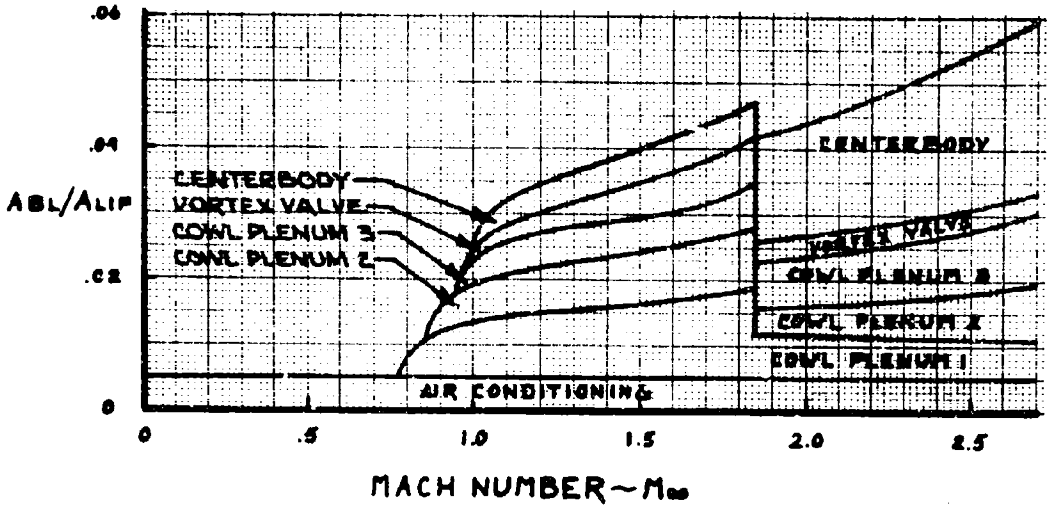
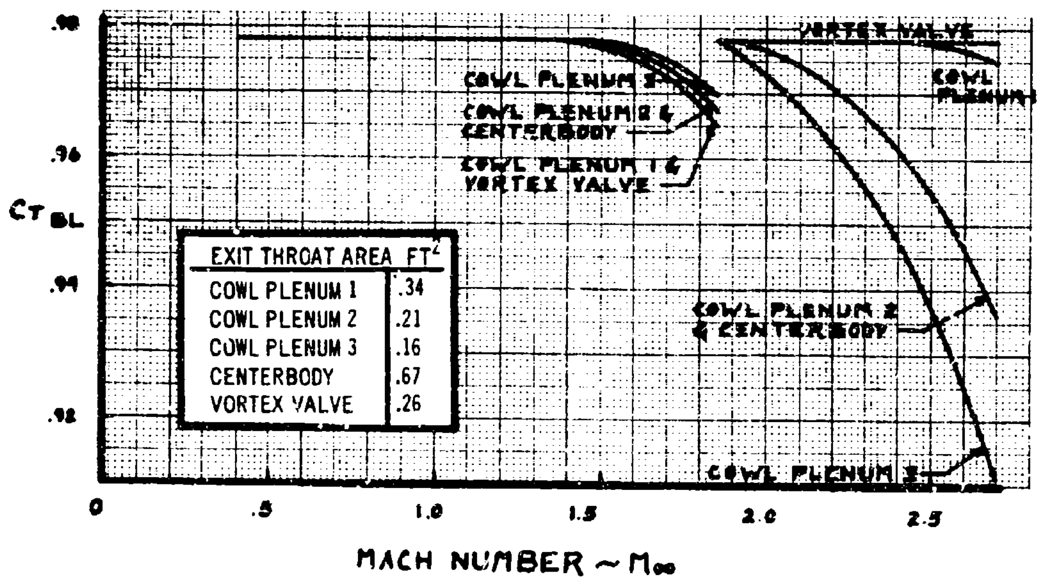



*Figure 35. Inlet Bleed Mass Flow Ratio*




| EXIT THROAT AREA | $FT^2$ |
|---|---|
| COWL PLENUM 1 | .34 |
| COWL PLENUM 2 | .21 |
| COWL PLENUM 3 | .16 |
| CENTERBODY | .67 |
| VORTEX VALVE | .26 |

*Figure 36. Inlet Bleed Exit Thrust Coefficient*

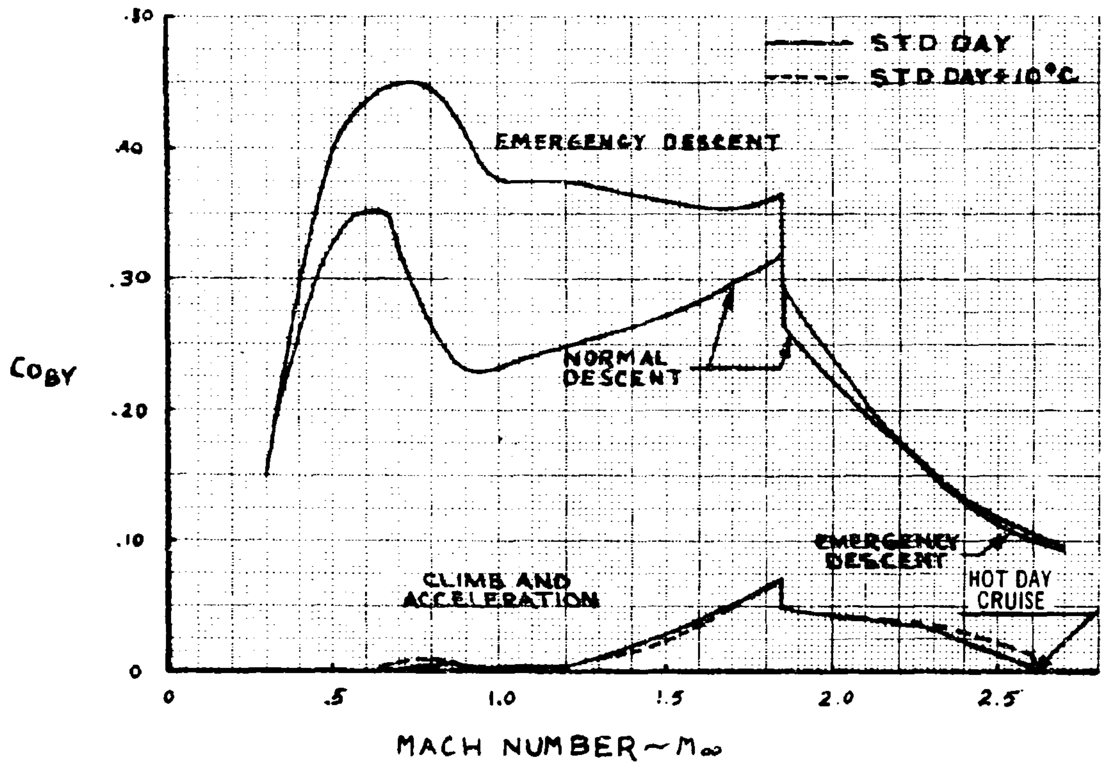



*Figure 37. Bypass Drag Coefficient*

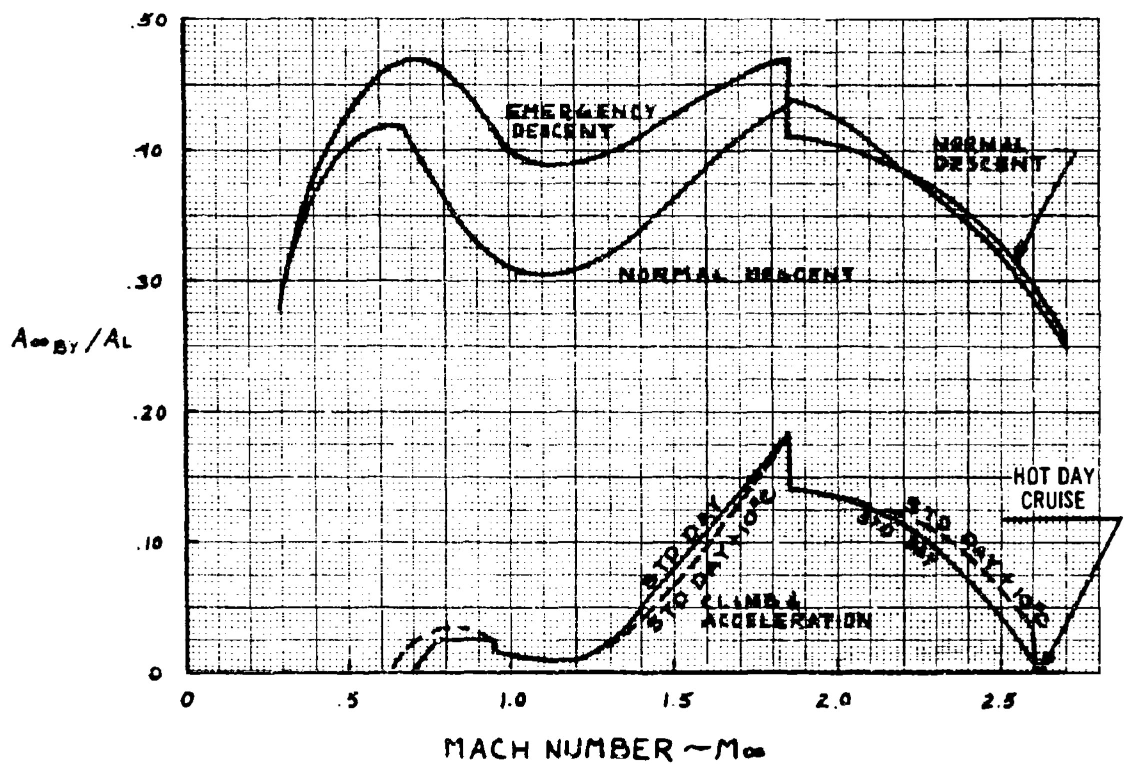



*Figure 38. Bypass Area Ratio*

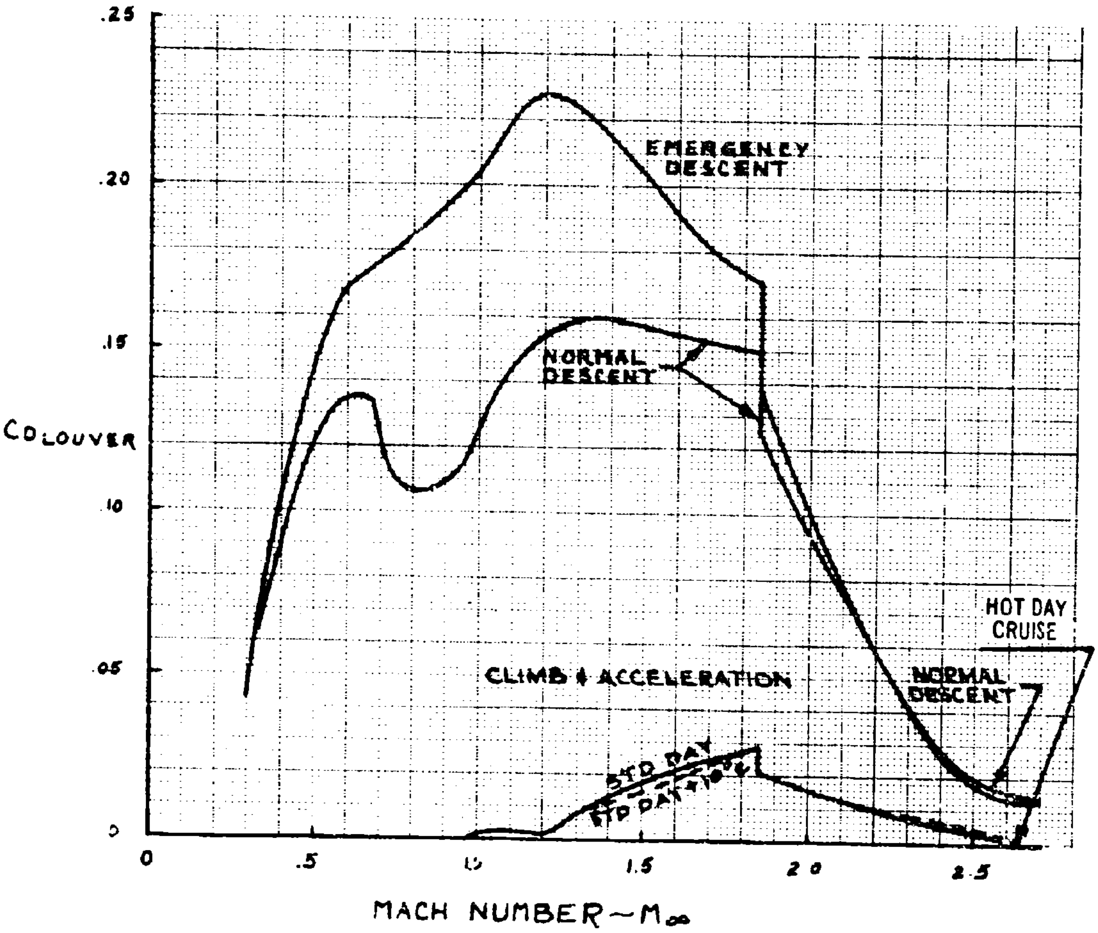



*Figure 39. Louver Wave Drag Coefficient*

$$\text{SINE } \bar{\theta}_{Louver} = \frac{A_{L_{BY}} \left(\frac{A}{A^*}\right)_{DIS}}{\left(\frac{A}{A^*}\right)_{Local} C_{DIS} \left(\frac{P_{T_{BY}}}{P_{T_\infty}}\right) S_{Louver}}$$

where $A_{L_{BY}}$ is defined in Par. 3.1.1.1.2.6.1

$\frac{P_{T_{BY}}}{P_{T_\infty}}$ is defined in Par. 3.1.1.1.2.6.3.3

$S_{Louver}$ is (1.02) ($A_{Lip}$)

$C_{DIS}$ is 1.05

$$\left(\frac{A}{A^*}\right)_{Local} = \frac{1}{M_L}\left(\frac{1 + .2M_L^2}{1.2}\right)^3$$

$$\left(\frac{A}{A^*}\right)_{DIS} = \frac{1}{M_{DIS}}\left(\frac{1 + .2M_{DIS}^2}{1.2}\right)^3$$

$M_{DIS}$ is the discharge Mach number at the louver exit.

3.1.1.1.2.6.3 Bypass Momentum Drag Coefficient. Bypass momentum drag coefficients are shown in Fig. 40. The bypass momentum drag coefficient was calculated from the equation:

$$C_{D_{MV}} = 2\left[1 - C_v \cos\theta_{DIS} \left(\frac{V_{IDEAL}}{V_{LOCAL}}\right)\right]\left(\frac{A_{L_{BY}}}{A_L}\right)\left(\frac{q_L}{q_\infty}\right)$$

Where: $V_{ideal}$ is the ideally expanded exit velocity (the nozzle back pressure is assumed to be $P_L$)

$V_{local}$ is the local air velocity just upstream of the inlet

$q_L$ is the local dynamic pressure ( $\frac{\gamma}{2} P_L M_L^2$ )

$q_\infty$ is the freestream dynamic pressure ( $\frac{\gamma}{2} P_\infty M_\infty^2$ )

$\gamma$ is 1.4

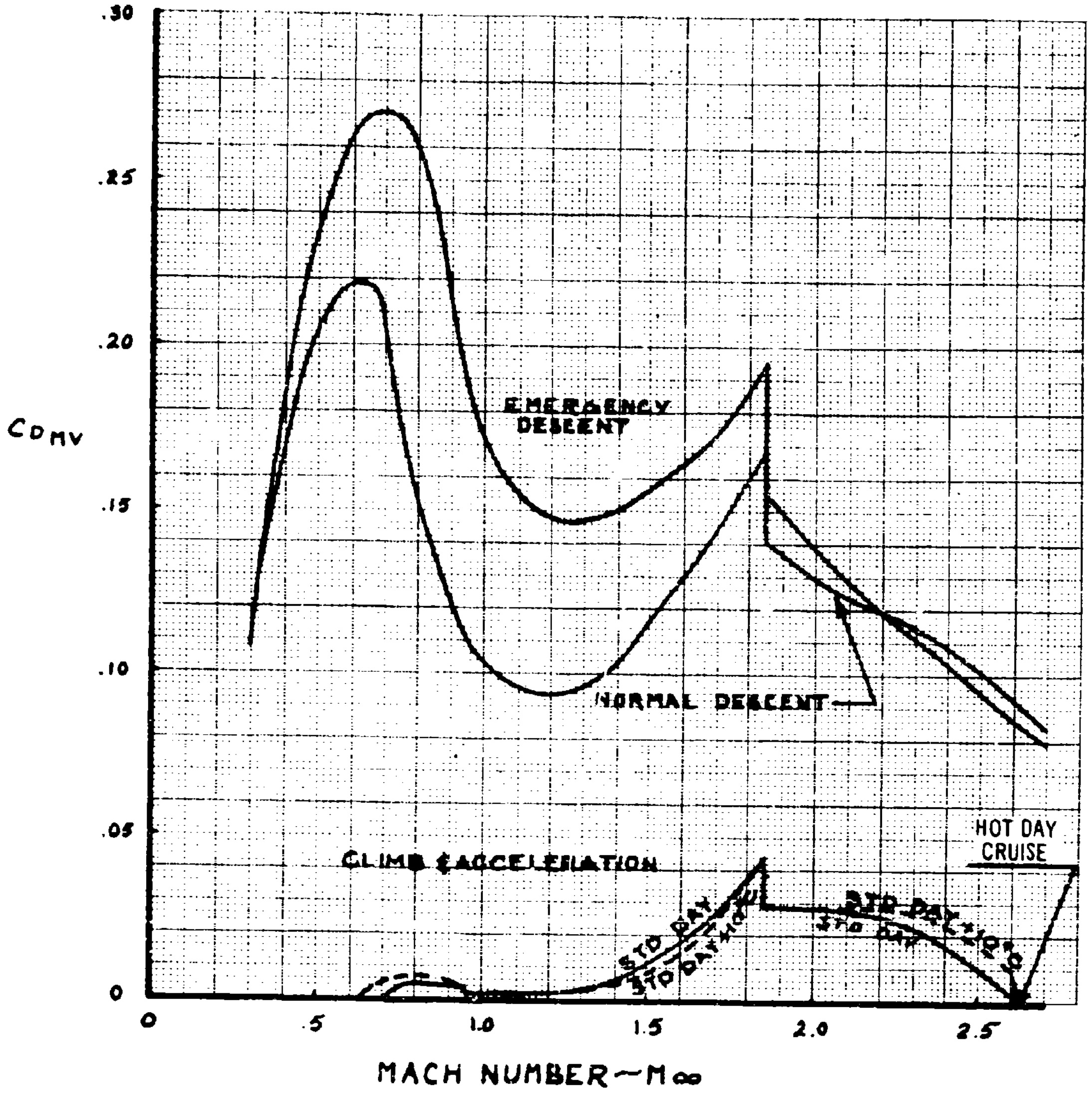



*Figure 40. Bypass Momentum Drag Coefficient*

$C_V$ is defined in Par. 3.1.1.1.2.6.3.1.

$\theta_{DIS}$ is defined in Par. 3.1.1.1.2.6.3.2.

$A_{L_{BY}}$ is defined in Par. 3.1.1.1.2.6.1.

3.1.1.1.2.6.3.1 Bypass Exit Velocity Coefficient. The bypass exit velocity, $C_V$, is shown in Fig. 41. $C_V$ includes under expansion losses, nozzle internal friction losses and velocity profile losses due to corner flow.

3.1.1.1.2.6.3.2 Bypass Exit Discharge Angle. The bypass exit discharge angles are shown in Fig. 42.

3.1.1.1.2.6.3.3 Bypass System Total Pressure Recovery. The bypass system estimated total pressure recovery is shown in Fig. 43. The bypass total pressure shall be 5 percent less than the total pressure behind the inlet normal shock during started inlet operation. During unstarted inlet operation the bypass total pressure shall be 6 percent less than the inlet throat total pressure.

3.1.1.1.3 Nozzle Performance Characteristics. Based on available data, the nozzle internal thrust coefficient and the nozzle external boattail drag are shown in Figs. 44, 45 and 46.

3.1.1.1.3.1 Nozzle Internal Thrust Coefficient. The nozzle internal thrust coefficient used for engine installed performance calculation is shown in Fig. 45. The coefficients are based on the secondary air flow schedule shown in Fig. 16.

3.1.1.1.3.2 Nozzle Boattail Drag. The nozzle boattail drag for all flight operating conditions shall be calculated by analytical methods which are established by aerodynamic theory (Ref. D6-7842) and by laboratory tests (Ref. D6-2559). The nozzle boattail drag coefficients are shown in Fig. 46. The nozzle boattail angle and nozzle pressure ratio used for calculating boattail drag are shown in Figs. 44 and 47, respectively.

3.1.2 Operability. Not applicable.

3.2 Subsystem Definition.

3.2.1 Interface Requirements. The propulsion subsystem performance interfaces are defined as analytical or functional interfaces. The subsystems defined below either take energy from, or add energy to, the propulsion performance subsystem.

3.2.1.1 Schematic Arrangement. The detailed interface schematic diagram for the B-2707 (GE) propulsion performance and adjoining subsystems is shown in Fig. 48.

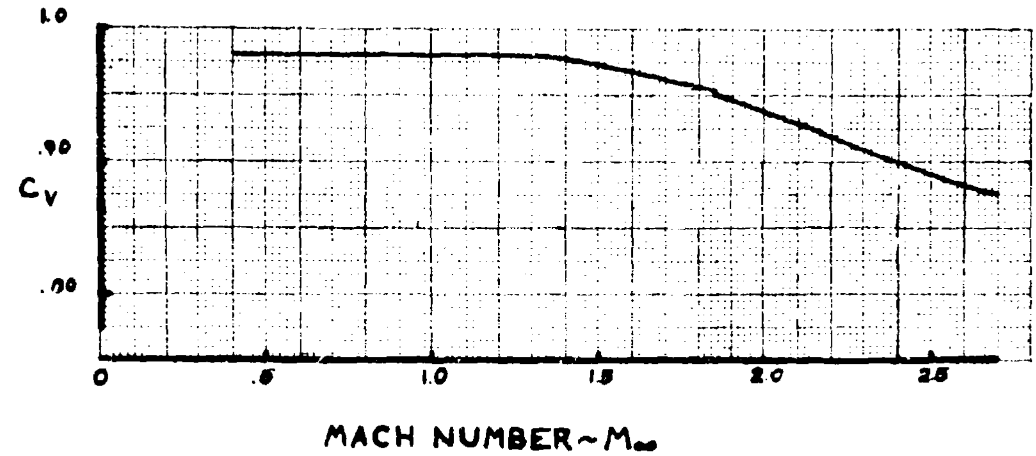



*Figure 41. Bypass Exit Velocity Coefficie*

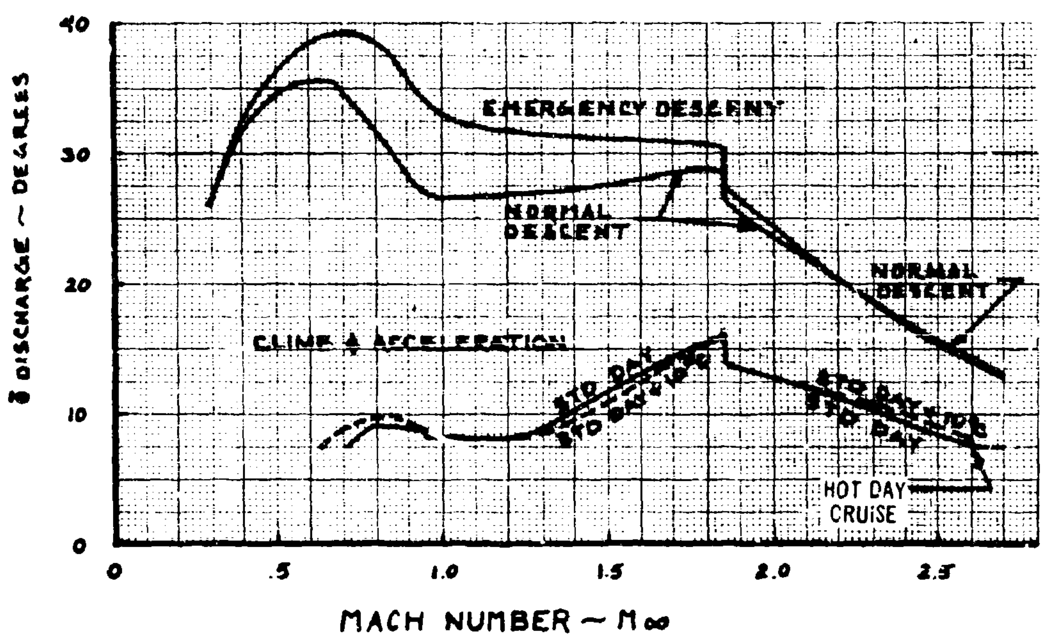



*Figure 42. Bypass Exit Discharge Angle*

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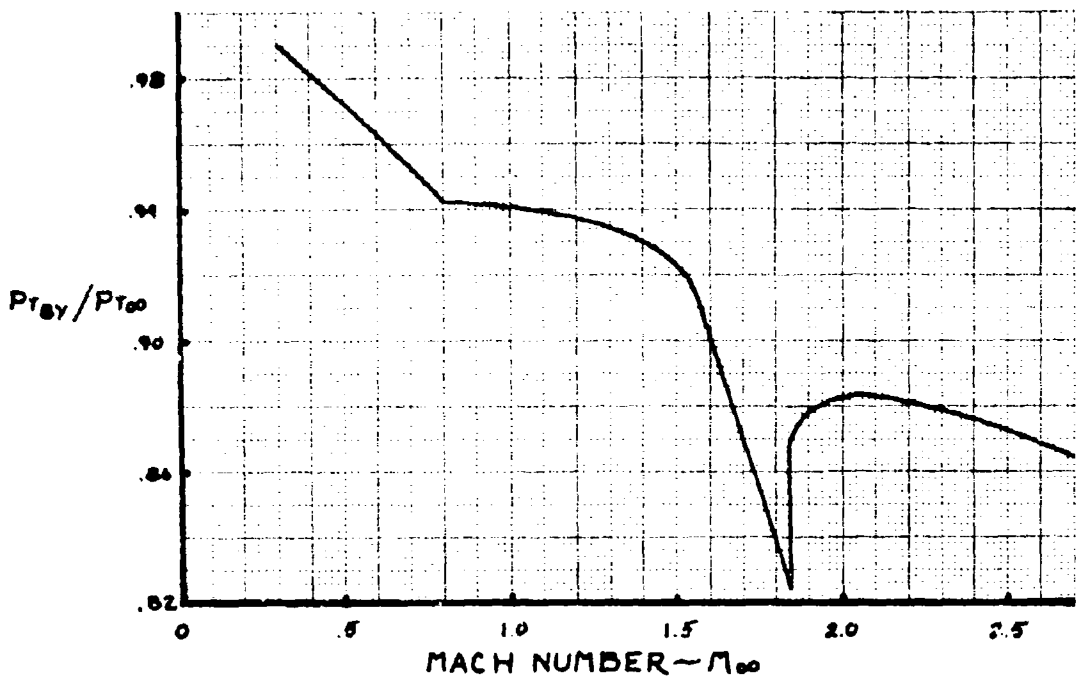


*Figure 43. Bypass Total Pressure Recovery*

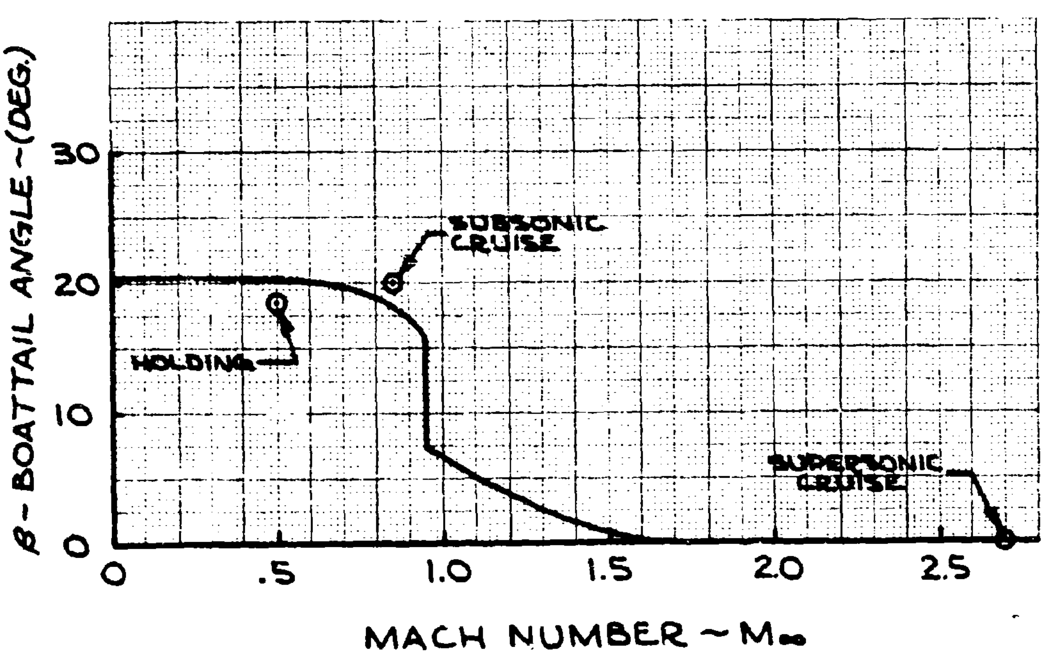


*Figure 44. Nozzle Boattail Angle*

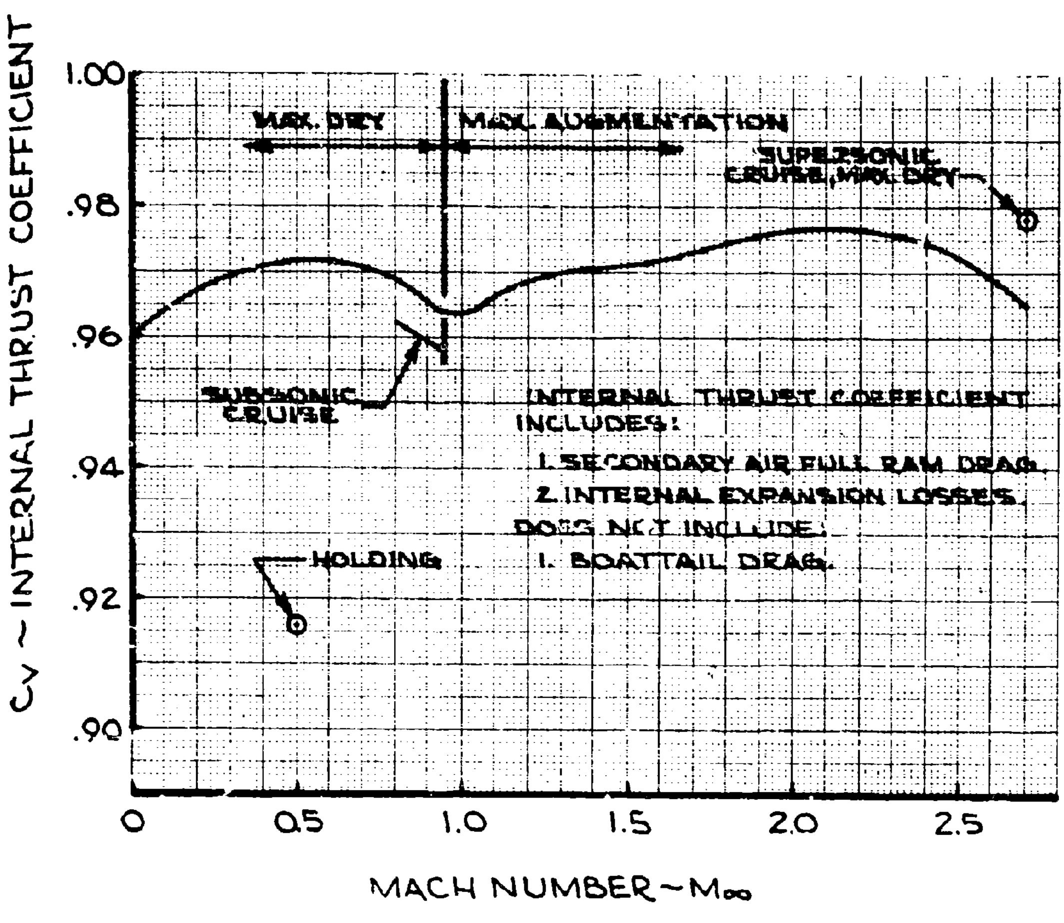


*Figure 45. Nozzle Internal Thrust Coefficient*

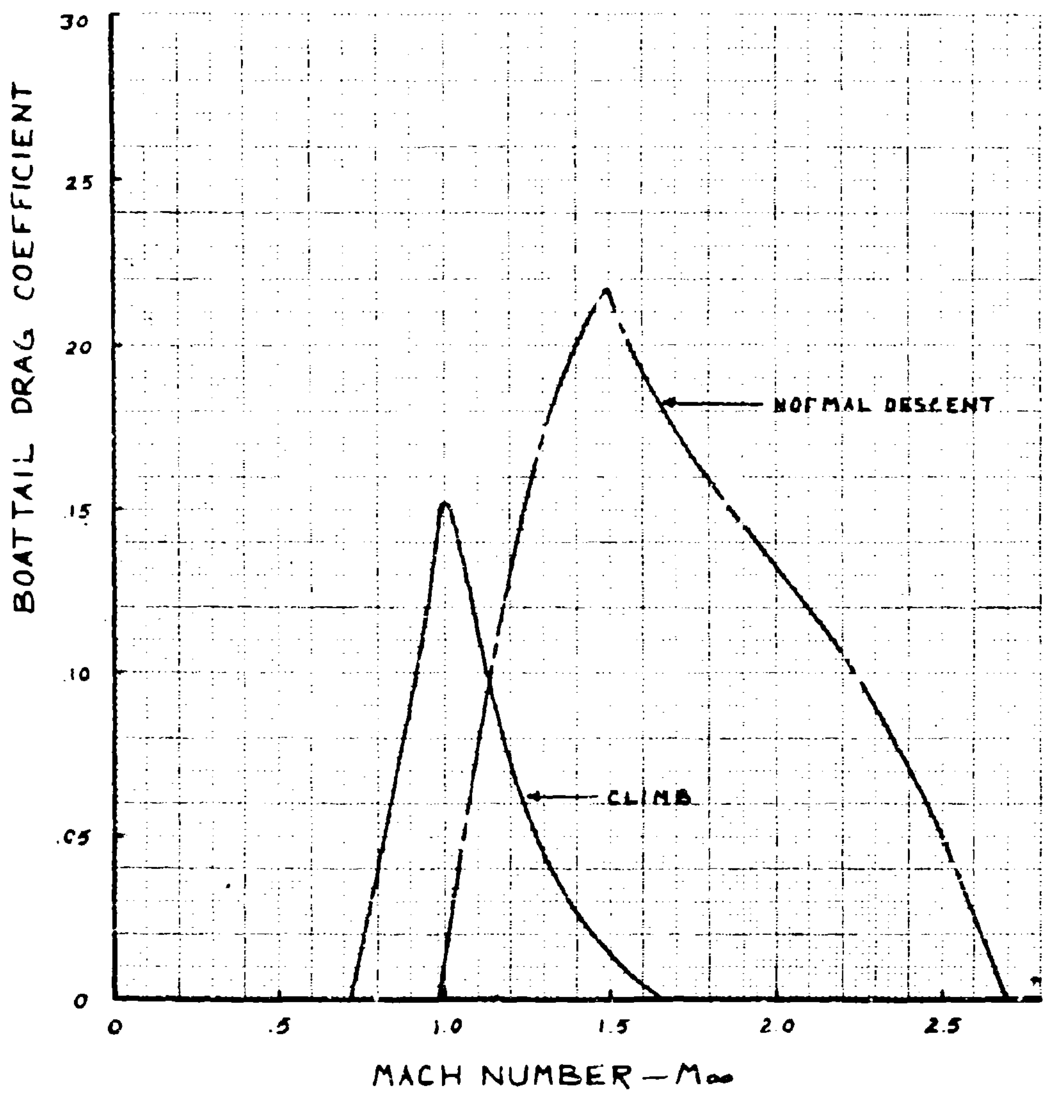


Figure 46. Nozzle Boattail Drag Coefficient

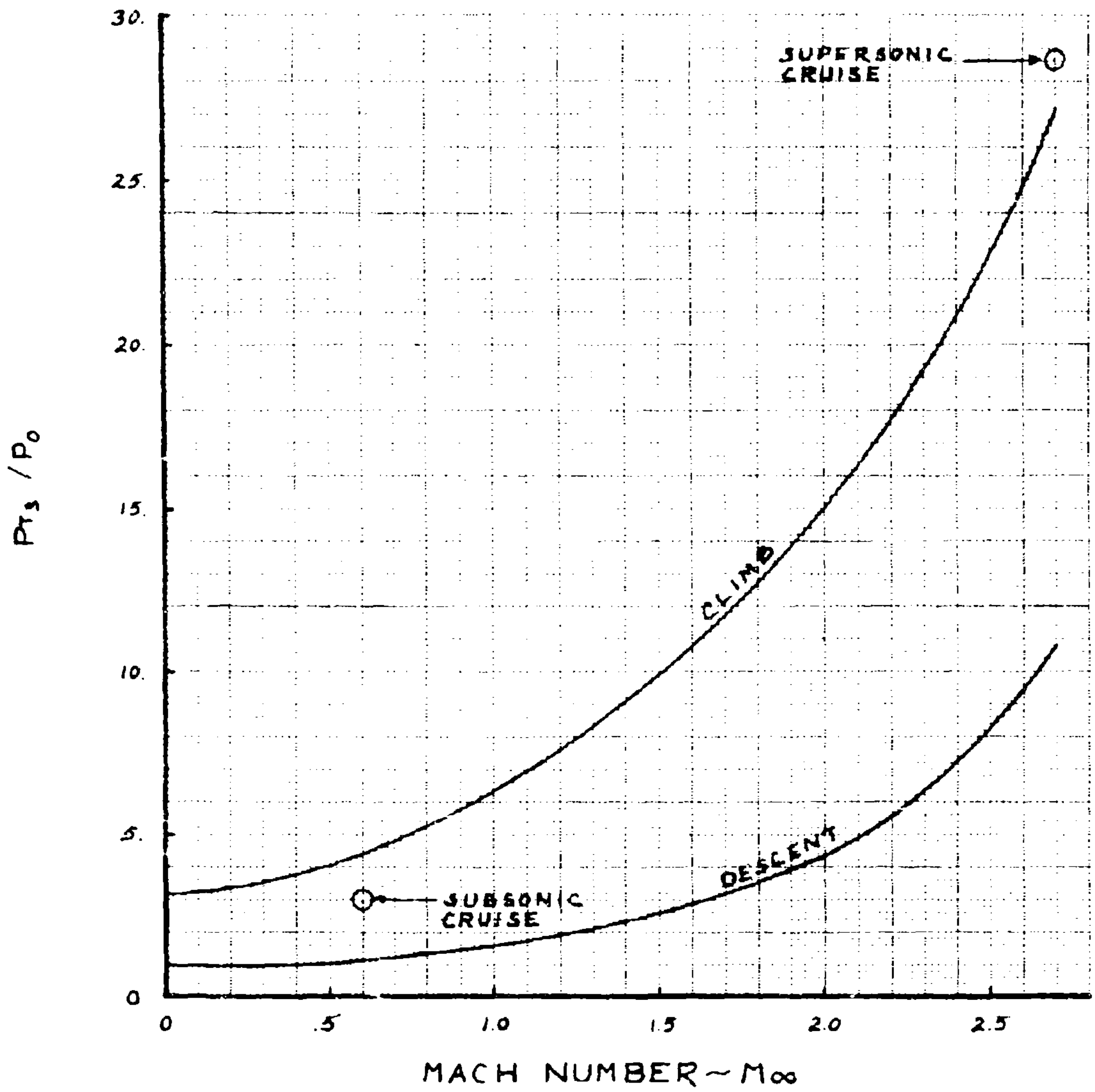


Figure 47. Nozzle Pressure Ratio

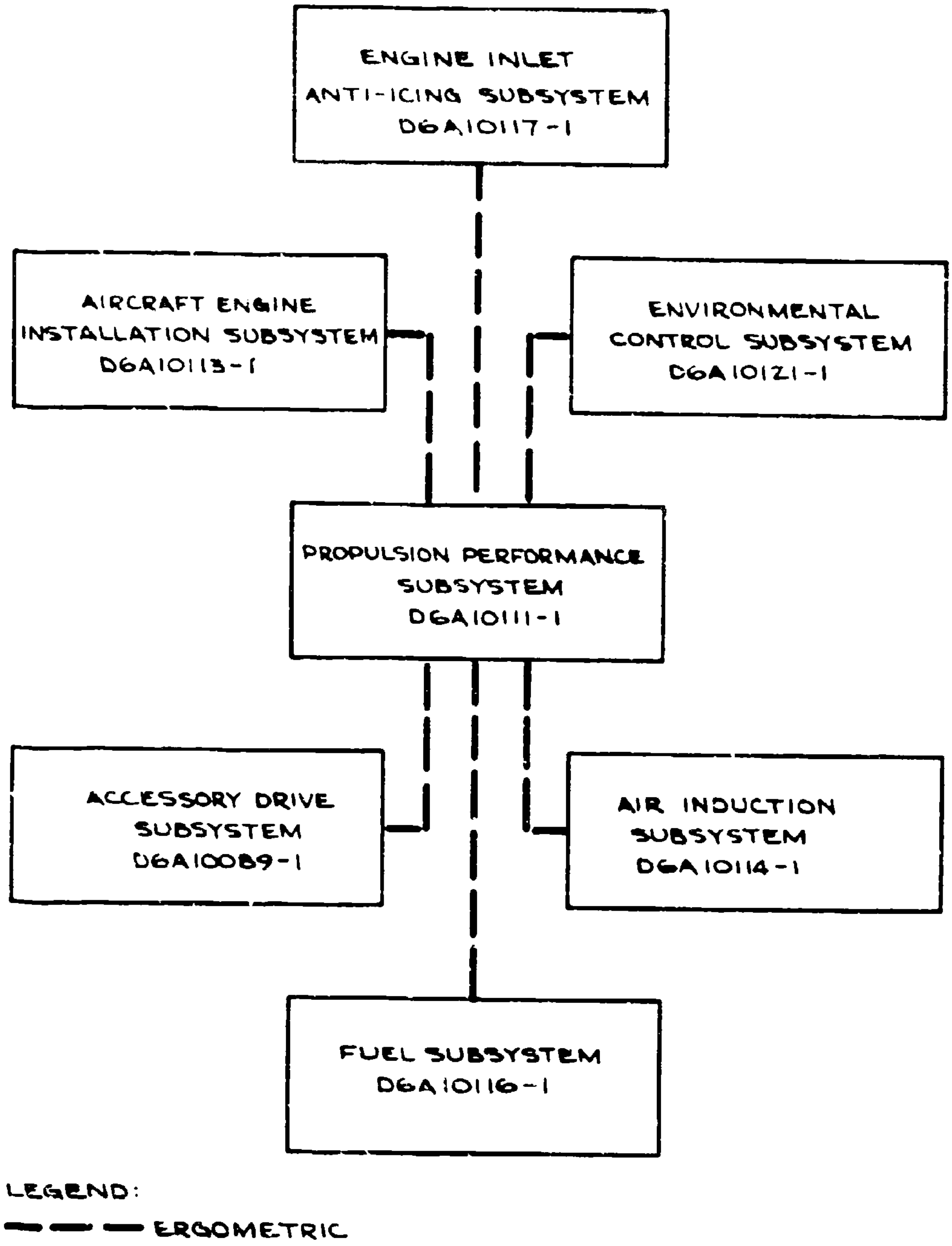


*Figure 48. Propulsion Subsystem Performance Interface Diagram*

3.2.1.2 Detailed Interface Definition. Not applicable.

3.3 Design and Construction. Not applicable.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Engineering Test and Evaluation.

4.1.1 Engine Test and Evaluation. Full scale engine tests, which are a part of D6A10198-1 Engine/Airframe Technical Agreement, conducted in a calibration stand and simulated altitude facility shall be used as a source of data to determine the effects of inlet recovery, inlet distortion, power extractions, and secondary airflow of Par. 3.1.1.1.

4.1.2 Inlet Performance. Model inlet tests shall be conducted to establish the spillage, bypass, and boundary layer bleed drag performance for selected operating conditions. The results of these tests shall be applicable to full scale inlet drag calculations and verify the performance calculations of Par. 3.1.1.1.

4.1.3 Nozzle Development. Model tests, which are a part of D6A10198-1 Engine/Airframe Technical Agreement, shall be conducted at selected operating conditions to establish nozzle performance characteristics. Data from full scale tests being performed for other purposes shall also be used.

4.2 Preliminary Qualification Testing. Not applicable.

4.3 Formal Qualification Tests. Not applicable.

4.4 Reliability Test and Analysis. Not applicable.

4.5 Performance Quality Verification Cross Reference Index. Not applicable.

## 5. PREPARATION FOR DELIVERY. Not applicable.

## 6. NOTES. Not applicable.

## SUPPLEMENT I

## PROTOTYPE SPECIFICATION

1. SCOPE

This supplement, together with the basic portion of this specification, defines the performance requirements for the prototype propulsion subsystem utilizing the General Electric Company engine performance of August 8, 1966. These requirements shall be the minimum acceptable to demonstrate the feasibility of the prototype propulsion subsystem.

Section and paragraph numbers appearing in this supplement are identical to those which appear in the basic specification. When no entry is made in this supplement for a specific entry in the basic Propulsion Performance Subsystem Specification, the entire paragraph shall also be applicable to the prototype subsystem. Portions of sections or paragraphs which are not applicable to the prototype subsystem are replaced, revised or deleted. Deletion of a major section or paragraph also deletes all subsections or subparagraphs thereunder without individual notation of deletion for each subsection or subparagraph.

2. APPLICABLE DOCUMENTS. No change.

3. REQUIREMENTS. Change.

3.1.1.1 Engine Performance Characteristics. Change to read:

The performance characteristics of the prototype engine shall be as shown in Table I and in Figs. 1 through 13, with the following exceptions:

a. The maximum net engine thrust at maximum augmented and maximum dry power settings shall not be less than 95 percent of the engine ratings shown in Table I of Par. 3.1.1.1.

b. The fuel flow for all thrust values shown in Table I, of Par. 3.1.1.1, shall not be more than 105 percent of the fuel flow at the same thrust value.

4. QUALITY ASSURANCE PROVISIONS. No change.

5. PREPARATION FOR DELIVERY. No change.

6. NOTES. No change.

## SUPPLEMENT II

## PRODUCTION SPECIFICATION

1. SCOPE

This supplement, together with the basic portion of this specification, defines the performance requirements for the production engine performance of October 7, 1966. The paragraphs in this supplement show the effect of the production engine performance data on the performance shown in the basic portion of this specification.

Section and paragraph numbers appearing in this supplement are identical to those which appear in the basic specification. When no entry is made in this supplement for a specific entry in the basic Propulsion Performance Subsystem Specification, the entire paragraph shall also be applicable to the production subsystem. Portions of sections or paragraphs which are not applicable to the production subsystem are replaced, revised or deleted. Deletion of a major section or paragraph also deletes all subsections or subparagraphs thereunder without individual notation of deletion for each subsection or subparagraph.

2.3 Other Publications. Change to read:

| | | |
|---|---|---|
| General Electric Co. | 7 Oct 1966 | Engine Performance Deck GE4/J5P Engine R66FPD 228E modified by incorporation of the GE4/J5 Study P Overlay Deck |
| General Electric Co. | 6 Sept 1966 | Engine Model Specification No. E-2056 modified to reflect the production engine performance. |

3.1.1.1 Engine Performance Characteristics. Change.

Replace Table I and Figure 1 through 12.

3.1.1.1.1 Performance Criteria. Change.

Replace Figure 16.

3.1.1.1.2.1 Engine Demand. Change.

Replace Figure 20

3.1.1.1.2.2 Inlet Supply - Engine Demand.

Replace Figure 21a and 21b.

3.1.1.1.2.3.1 Climb and Acceleration, Standard Day. Change

Replace Figure 23

3.1.1.1.2.3.2 Climb and Acceleration, Standard Day + 10°C. Change.

Replace Figure 24

**Table SII-1 Engine Performance**

| Power Setting | Pressure Altitude (Ft) | Ambient Temp. | Mach Number | Inlet Ram Recovery | Net Thrust (lb) | S.F.C. lb/hr/lb | Airflow lb/sec | Power Extraction H.P. | Secondary Air lb/sec | Bleed Air lb/sec |
|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Augmented | 0 | Std. | 0 | 0.96 | 63,160 | 1.90 | 608 | 450 | 64 | 0 |
| Maximum Non-Augmented | 0 | Std. | 0 | 0.96 | 47,700 | 1.07 | 607 | 450 | 31 | 0 |
| Maximum Augmented | 0 | Std. +40°F | 0 | 0.96 | 54,800 | 1.93 | 544 | 450 | 65 | 0 |
| Maximum Non-Augmented | 0 | Std. +40°F | 0 | 0.96 | 41,300 | 1.07 | 543 | 450 | 29 | 0 |
| Maximum Augmented | 45,000 | Std. | 1.2 | 0.986 | 23,700 | 1.85 | 225 | 450 | 13 | 0 |
| Maximum Augmented | 45,000 | Std. +10°C | 1.2 | 0.986 | 22,200 | 1.85 | 220 | 450 | 13 | 0 |
| Partial Augmented | 65,000 | Std. | 2.7 | 0.91 | 15,000 | 1.51 | 291 | 450 | 8.7 | 0 |
| Partial Augmented | 65,000 | Std. +10°C | 2.61 | 0.914 | 15,000 | 1.63 | 253 | 450 | 24 | 0 |
| Partial Non-Augmented | 36,150 | Std. | 0.85 | 0.99 | 5,000 | 1.11 | 163 | 450 | 13 | 0 |
| Partial Non-Augmented | 15,000 | Std. | 0.50 | 0.988 | 5,000 | 1.35 | 235 | 450 | 17 | 0 |
| Idle | 0 | Std. | 0 | 0.97 | 1,530 | * | 139 | 300 | 7.0 | [illegible].1 |
| Idle | 50,000 | Std. | 1.2 | 0.986 | -760 | ** | 87 | 500 | 5.7 | 1.85 |
| Maximum Reverse | 0 | Std. | 0 | 0.96 | 23,700 | *** | 607 | 550 | 31 | 2.1 |

* $W_f$ = [illegible],440 lb/hr
** $W_f$ = 1,440 lb/hr
*** $W_f$ = 50,900 lb/hr

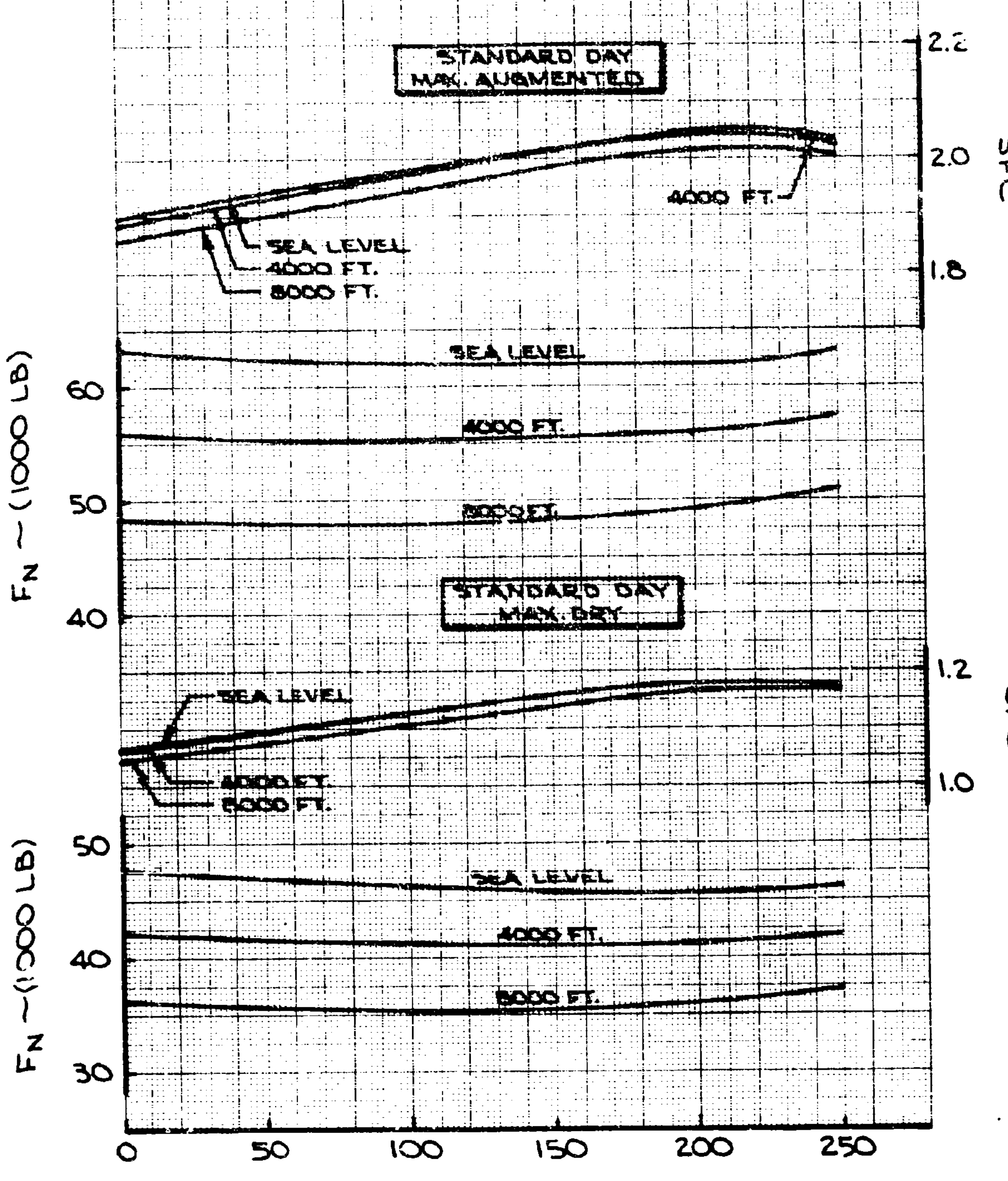


*Figure SII-1. Takeoff Thrust and SFC, Standard Day*

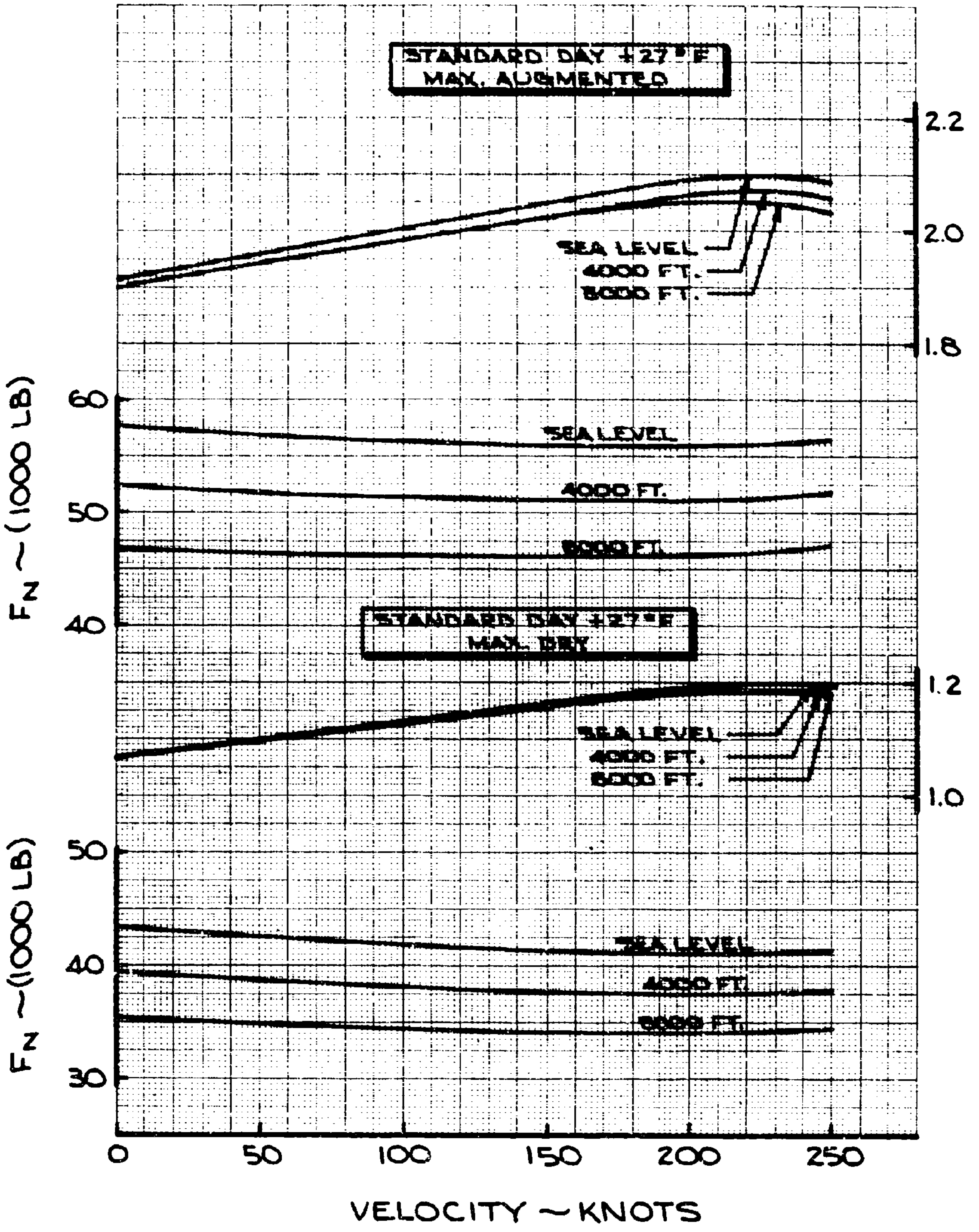


*Figure SII-2. Takeoff Thrust and SFC, Standard Day + 27°F*

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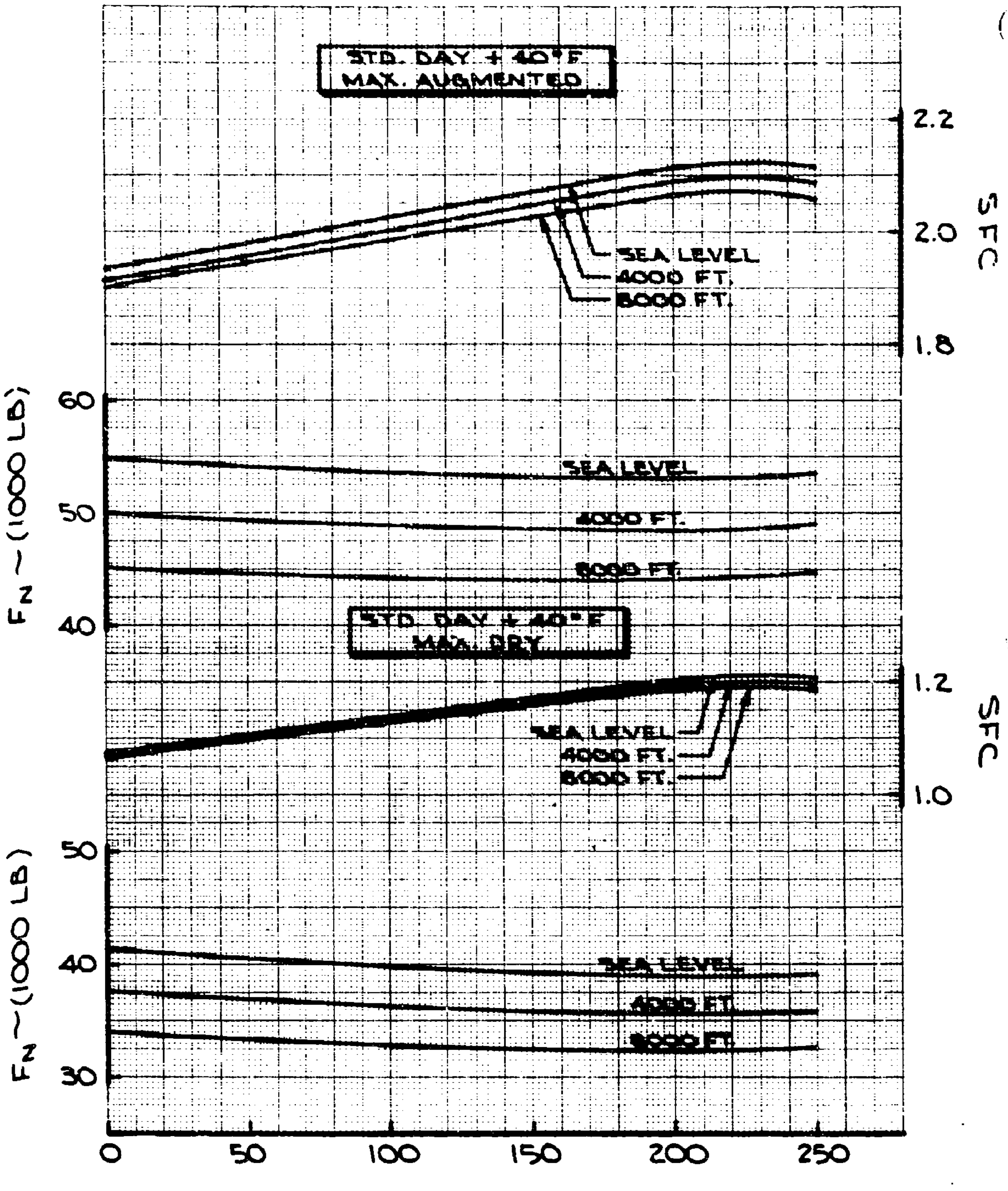


*Figure SII – 3. Takeoff Thrust and SFC, Standard Day + 40°F*

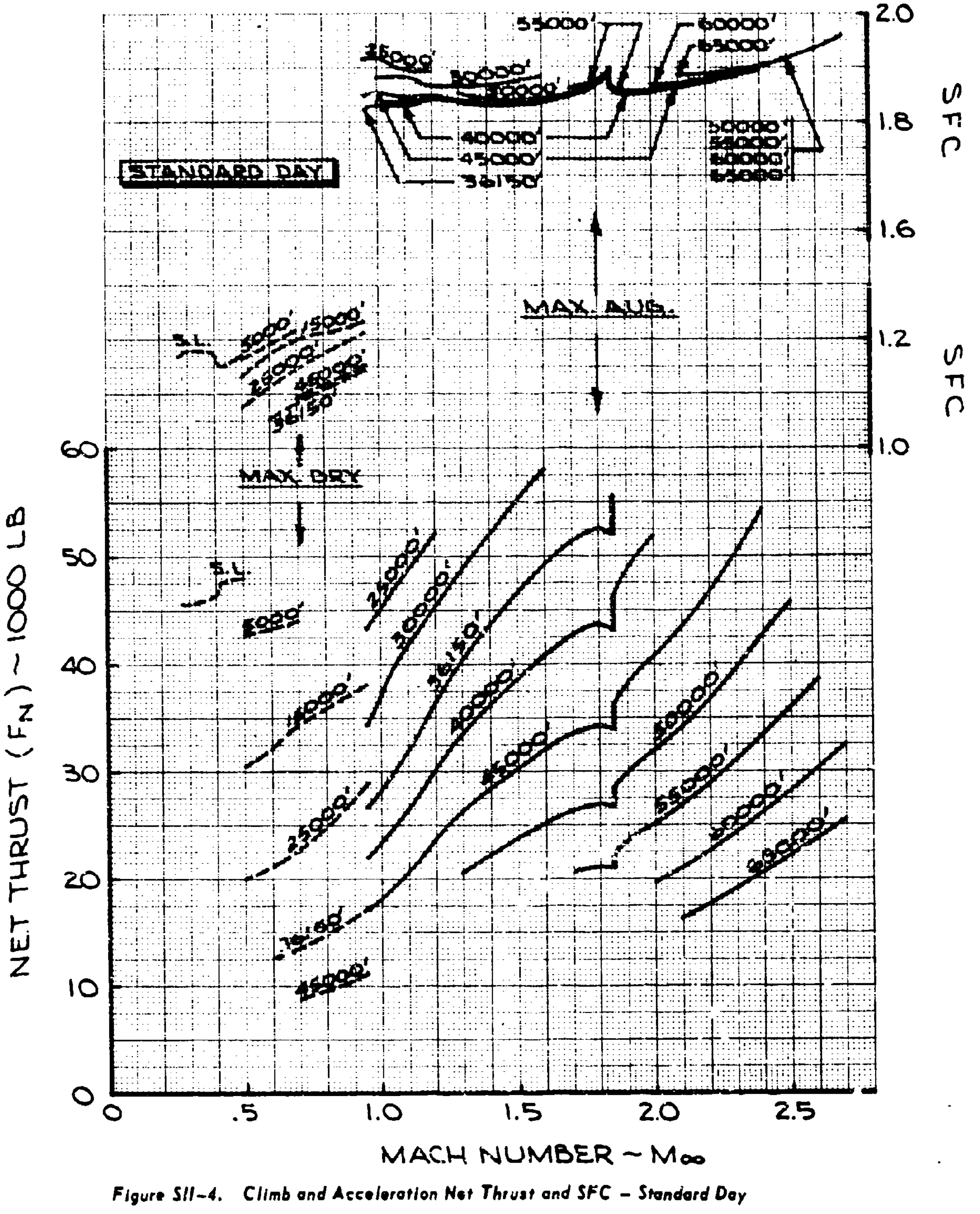


*Figure SII-4. Climb and Acceleration Net Thrust and SFC – Standard Day*

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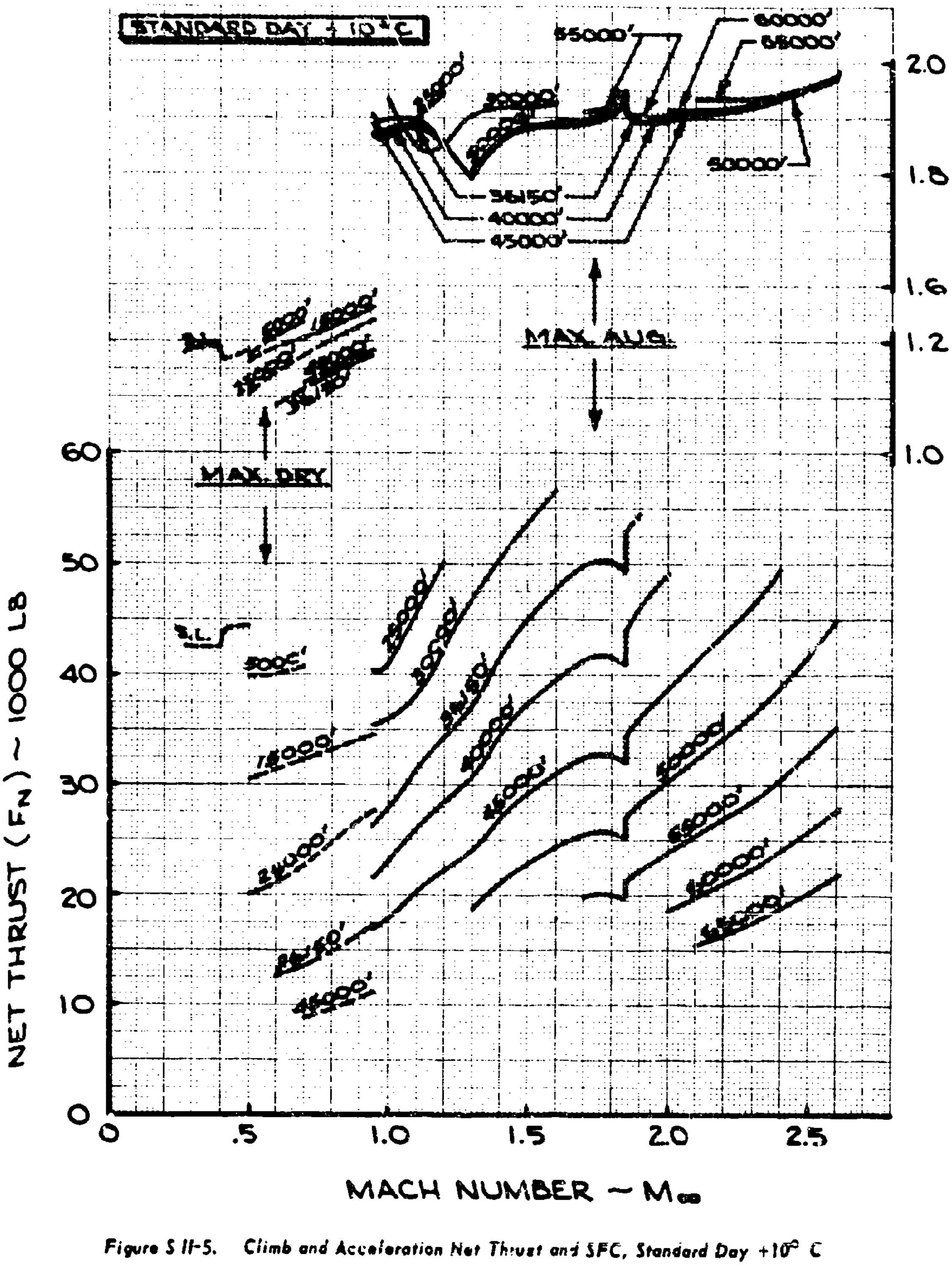


*Figure S II-5. Climb and Acceleration Net Thrust and SFC, Standard Day +10° C*

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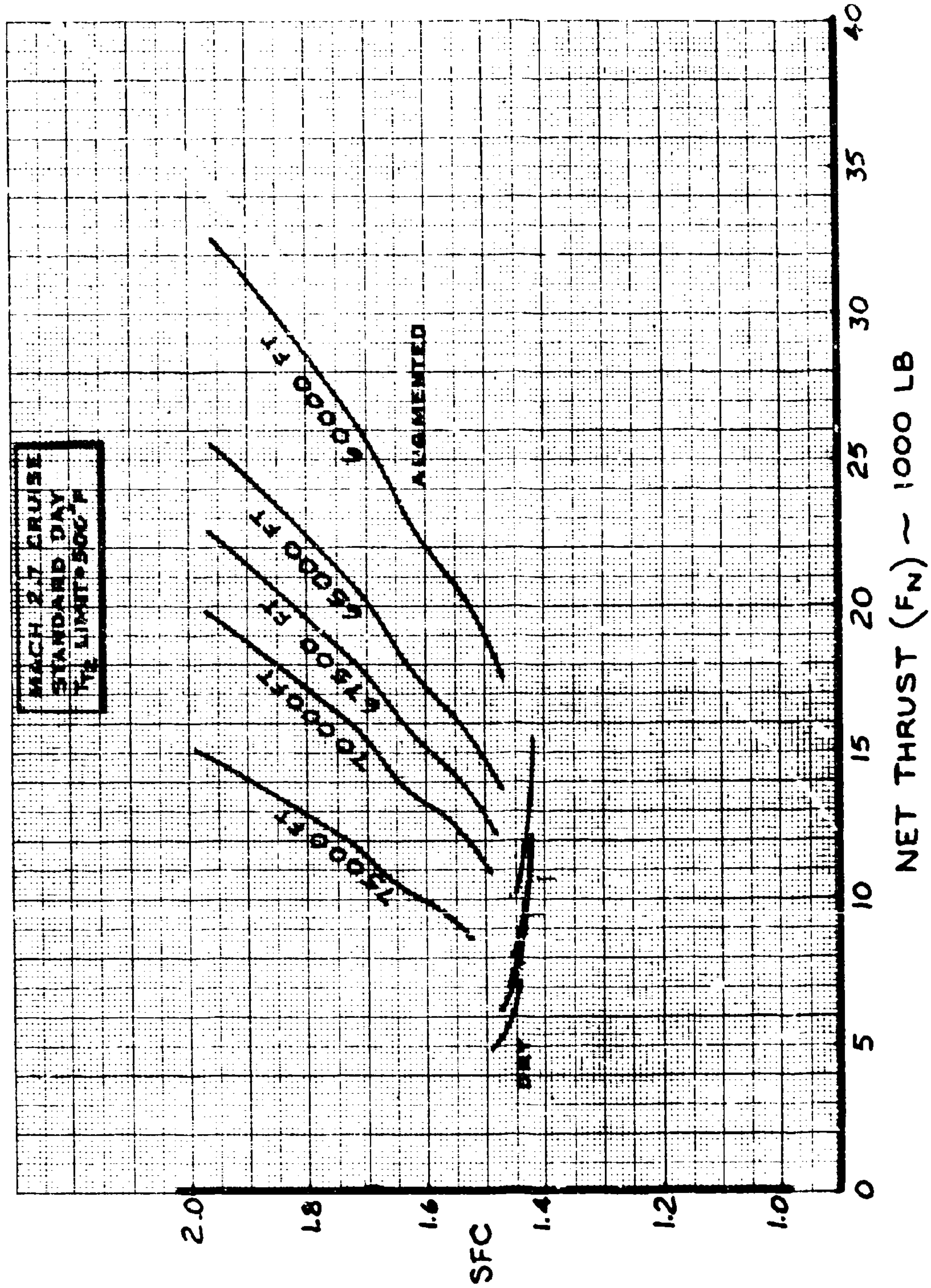


*Figure SII-6. Cruise Net Thrust and SFC – Standard Day*

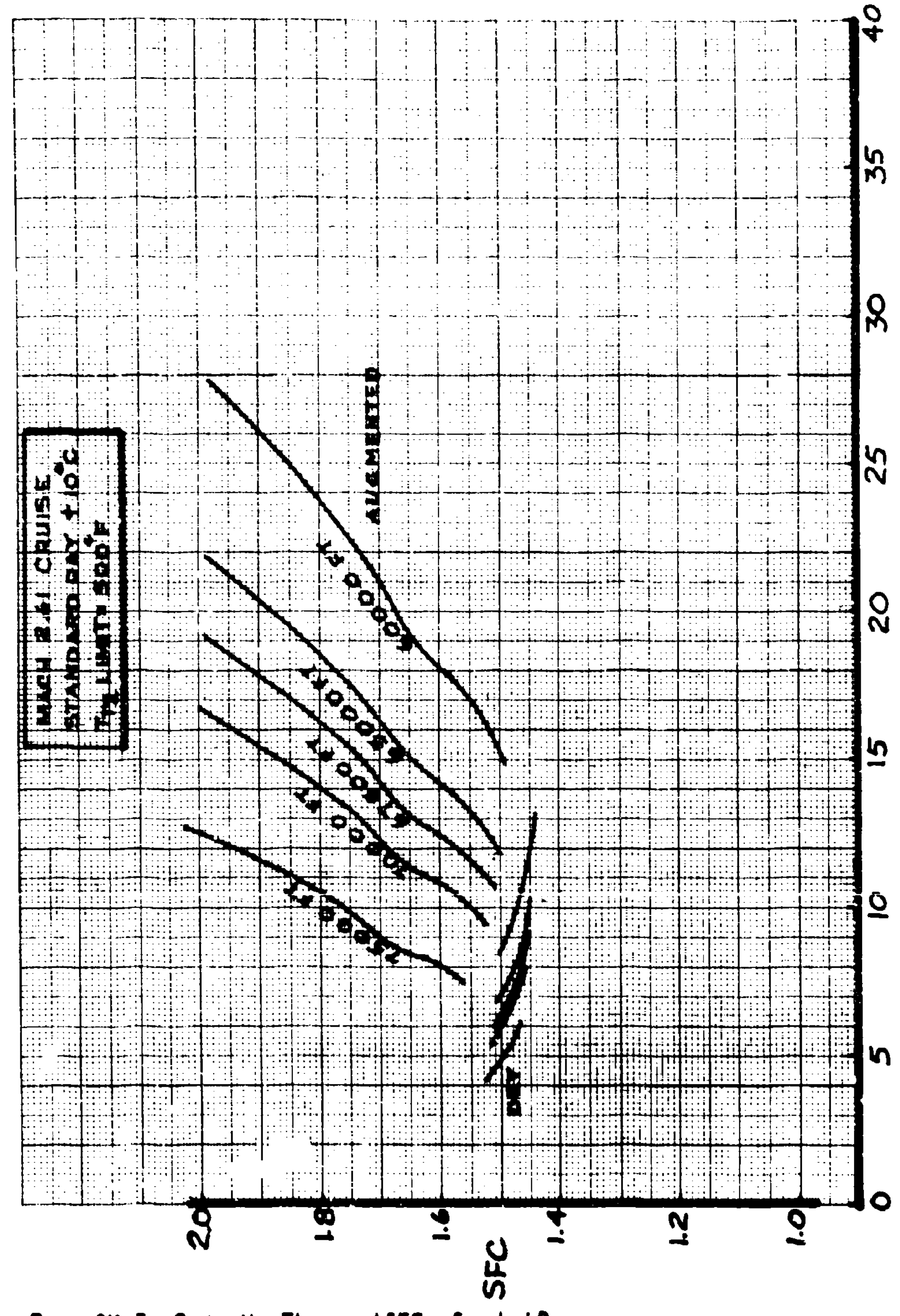


*Figure SII-7. Cruise Net Thrust and SFC – Standard Day*

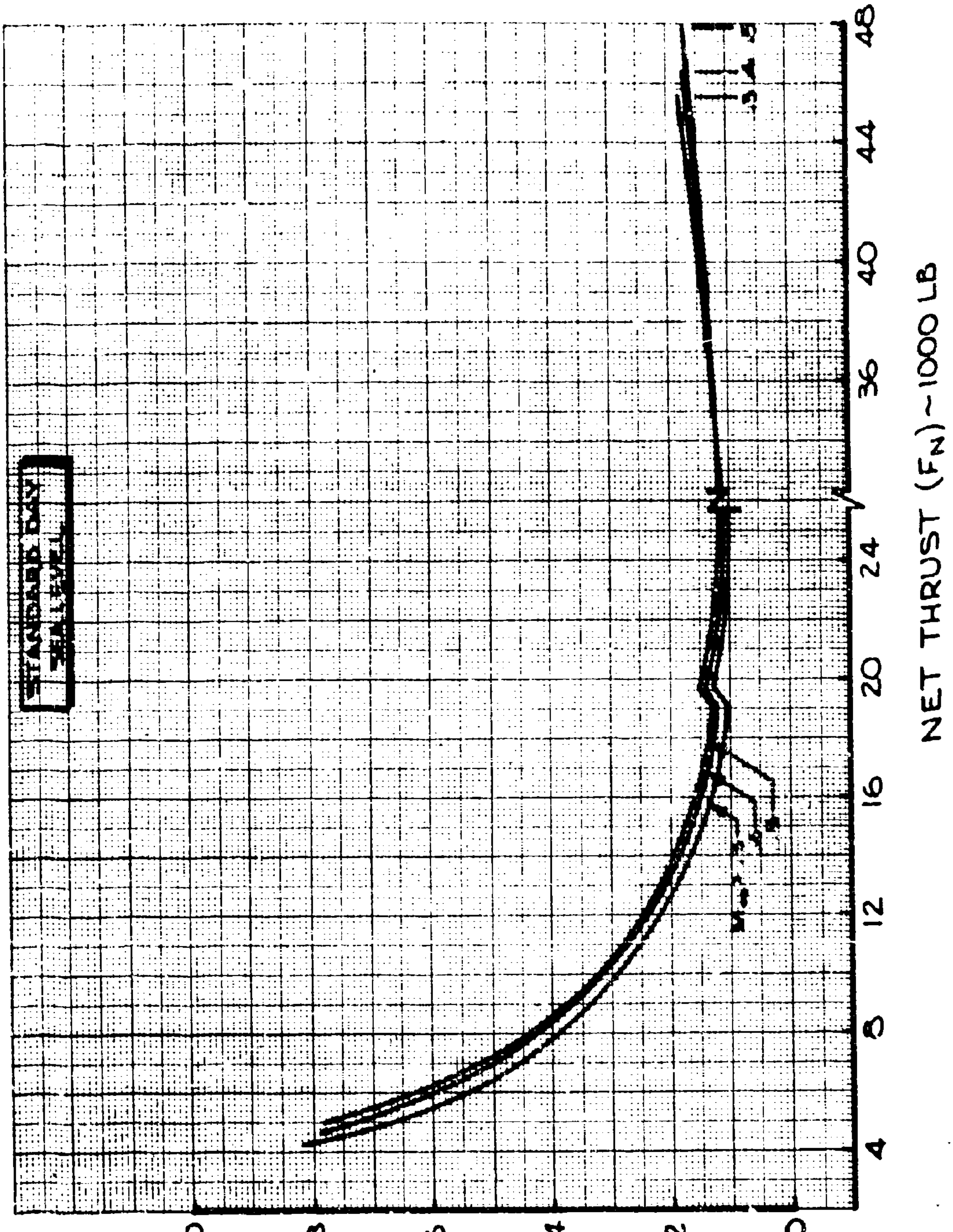


*Figure SII-8. Subsonic Net Thrust and SFC, Sea Level*

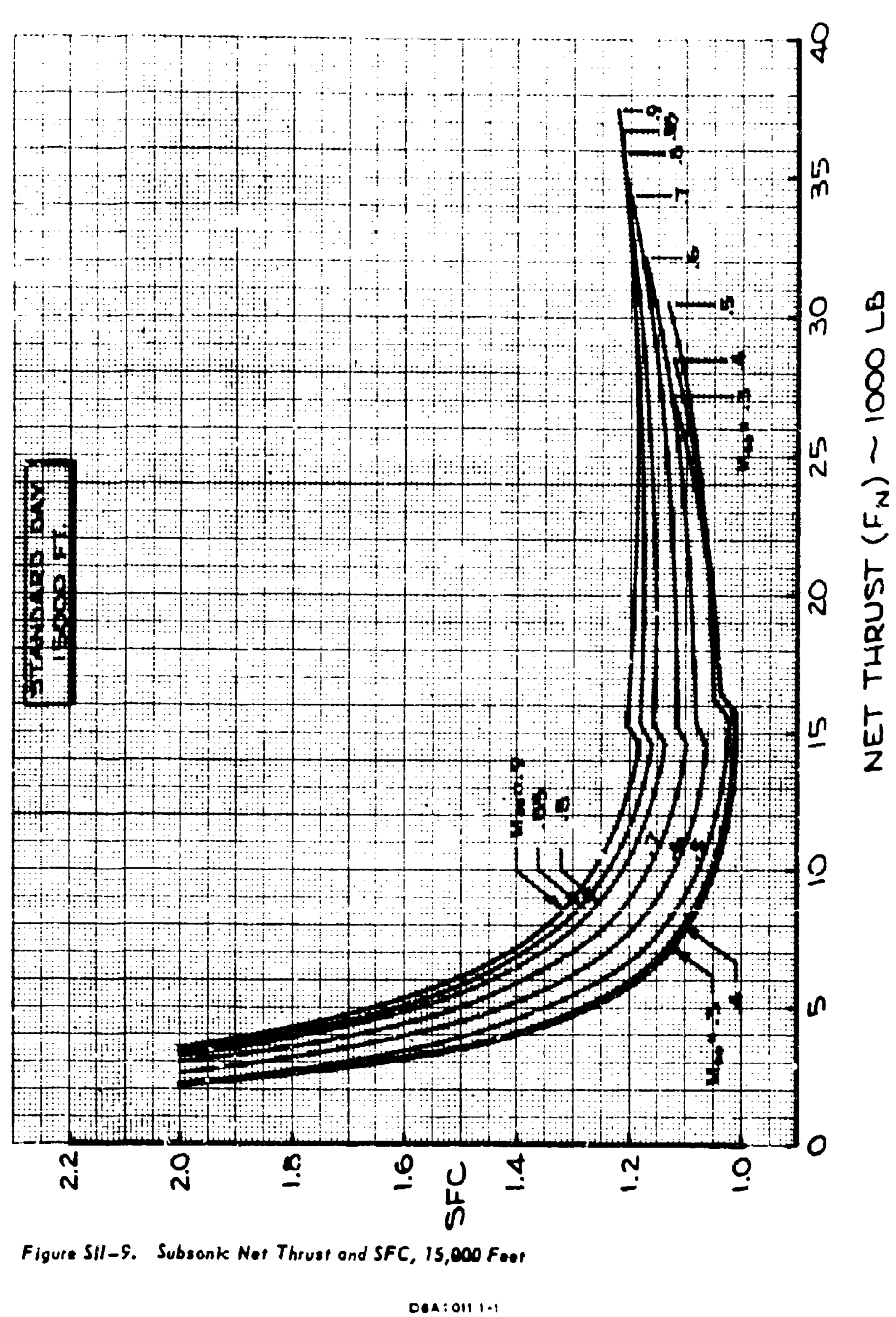


*Figure SII-9. Subsonic Net Thrust and SFC, 15,000 Feet*

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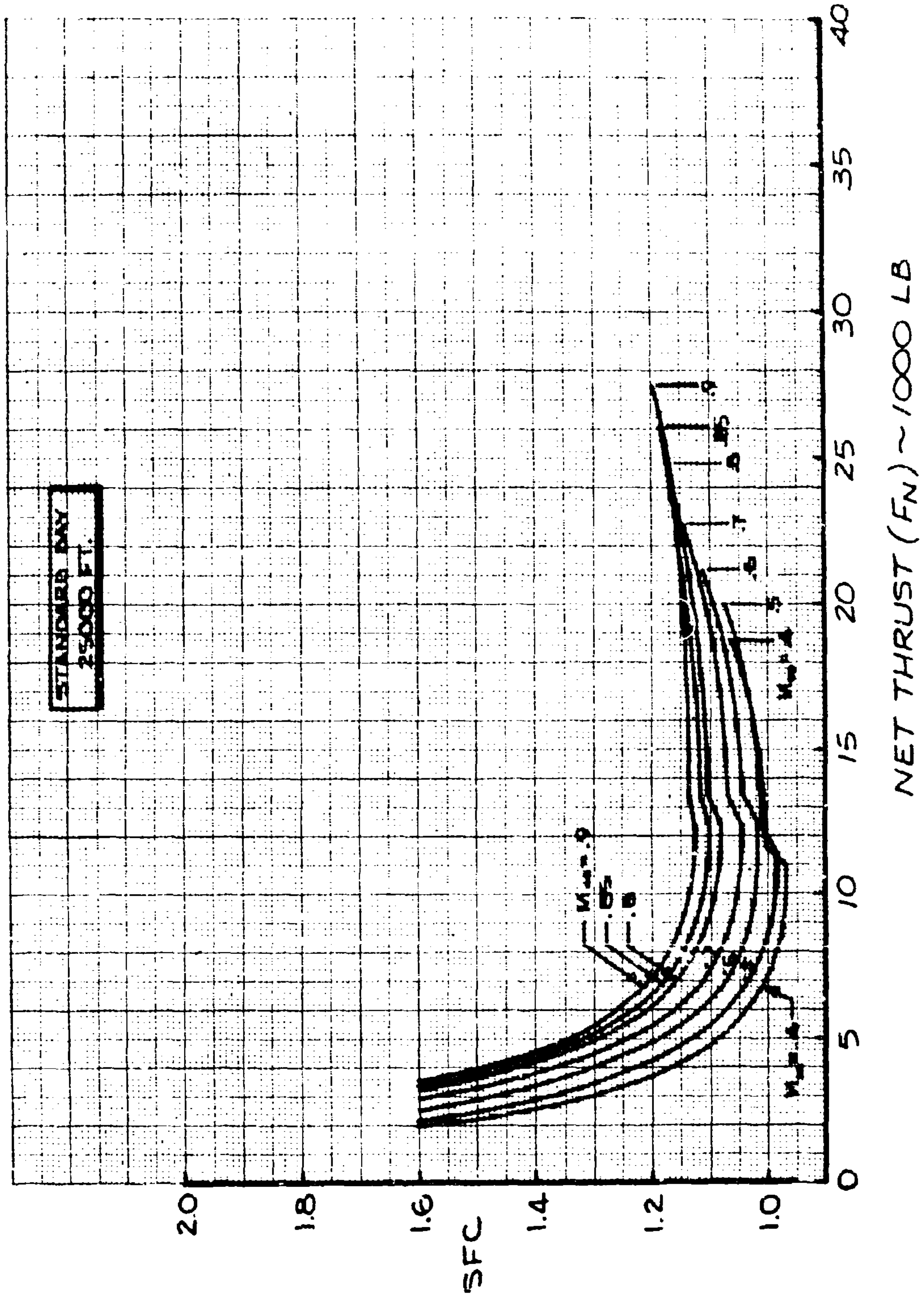


*Figure SII-10. Subsonic Net Thrust and SFC, 25,000 Feet*

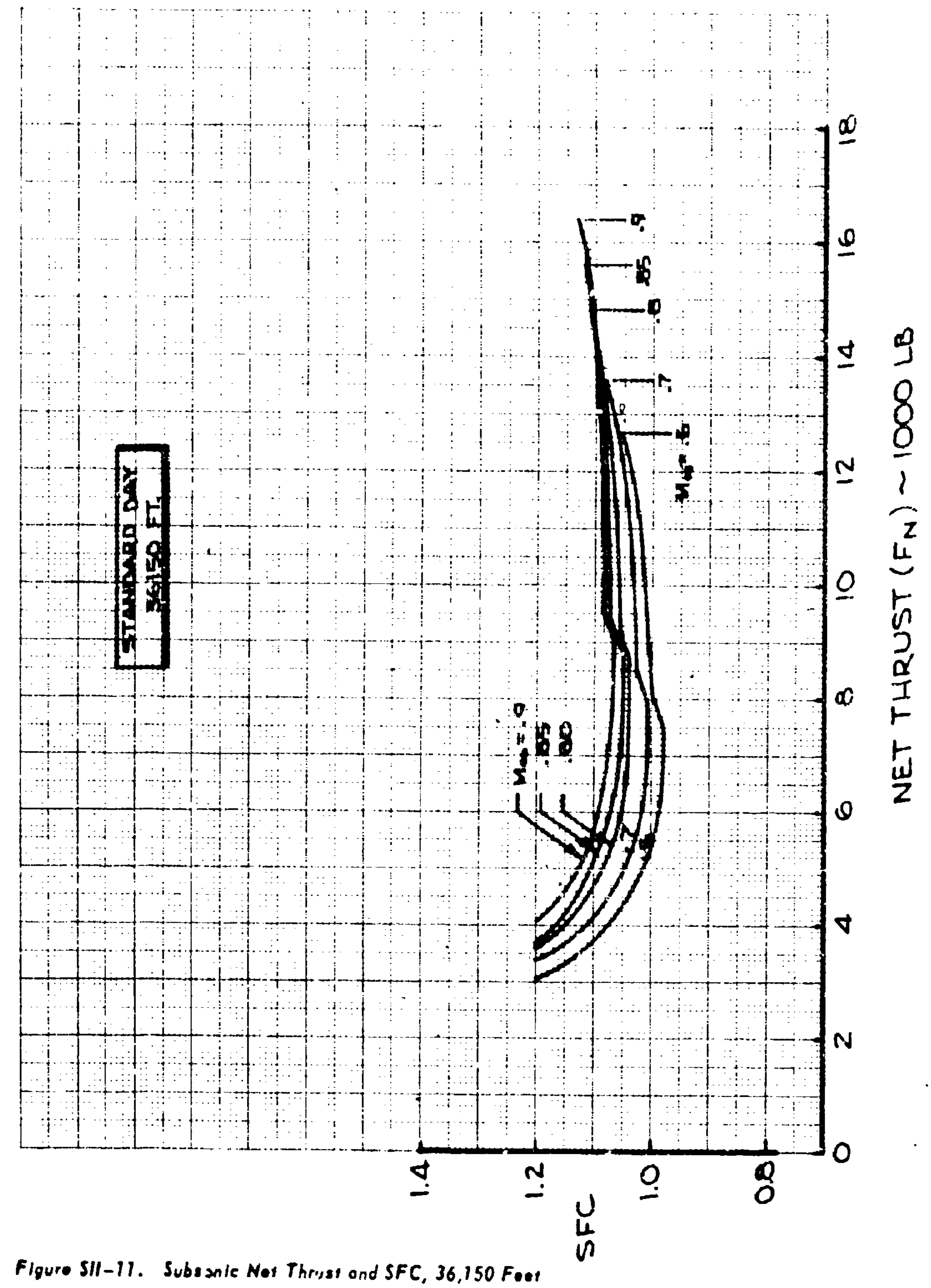


*Figure SII-11. Subsonic Net Thrust and SFC, 36,150 Feet*

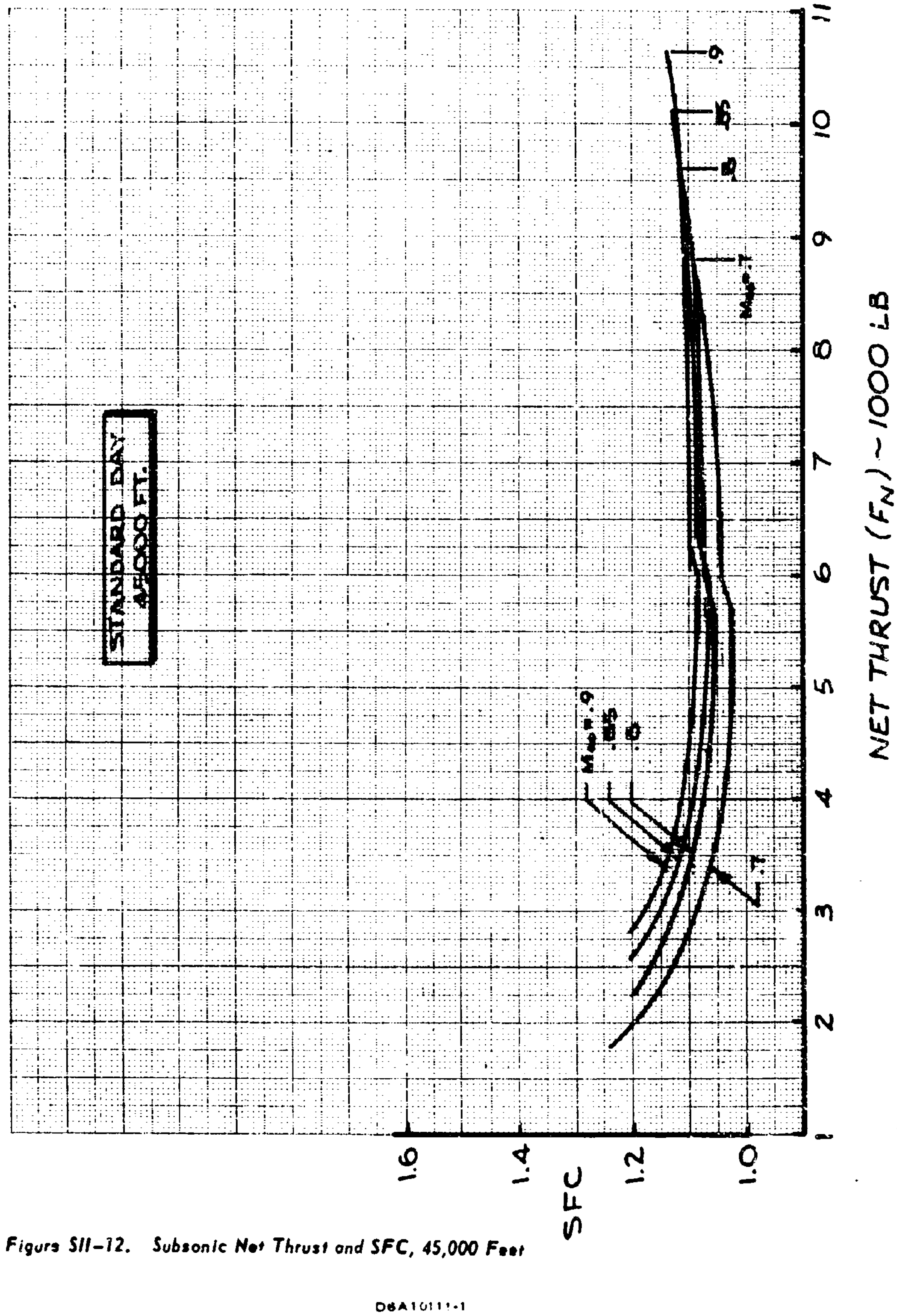


*Figure SII-12. Subsonic Net Thrust and SFC, 45,000 Feet*

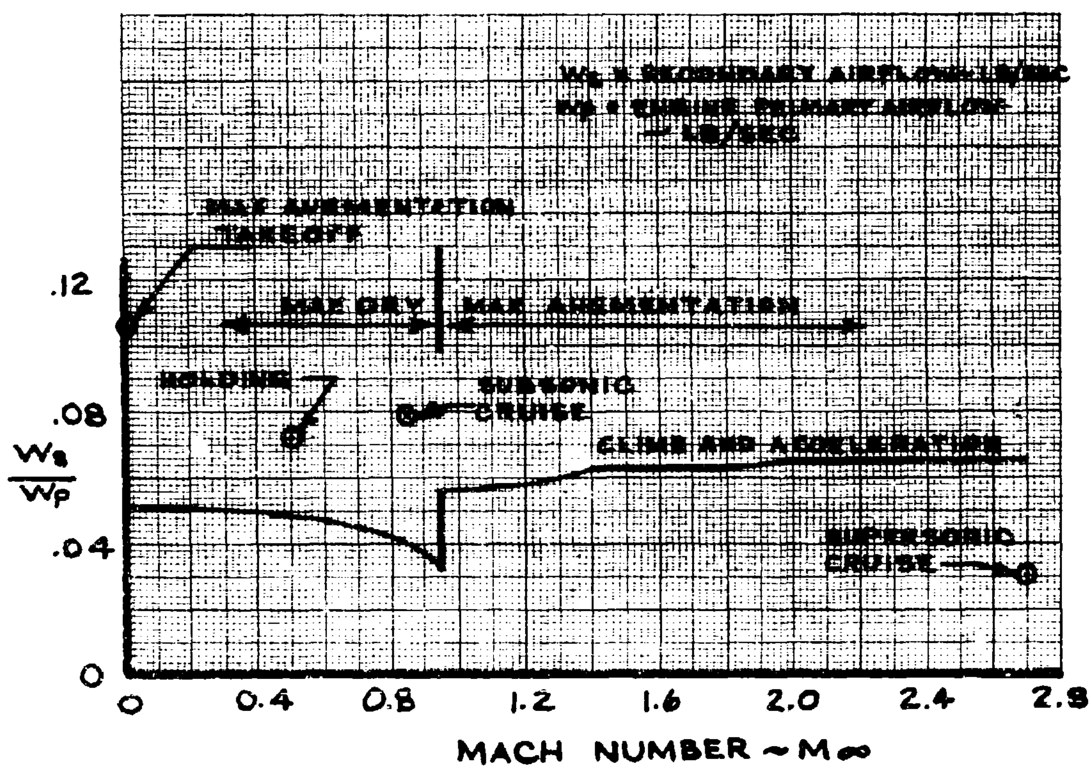


*Figure SII--16. Nozzle Secondary Airflow Schedule*

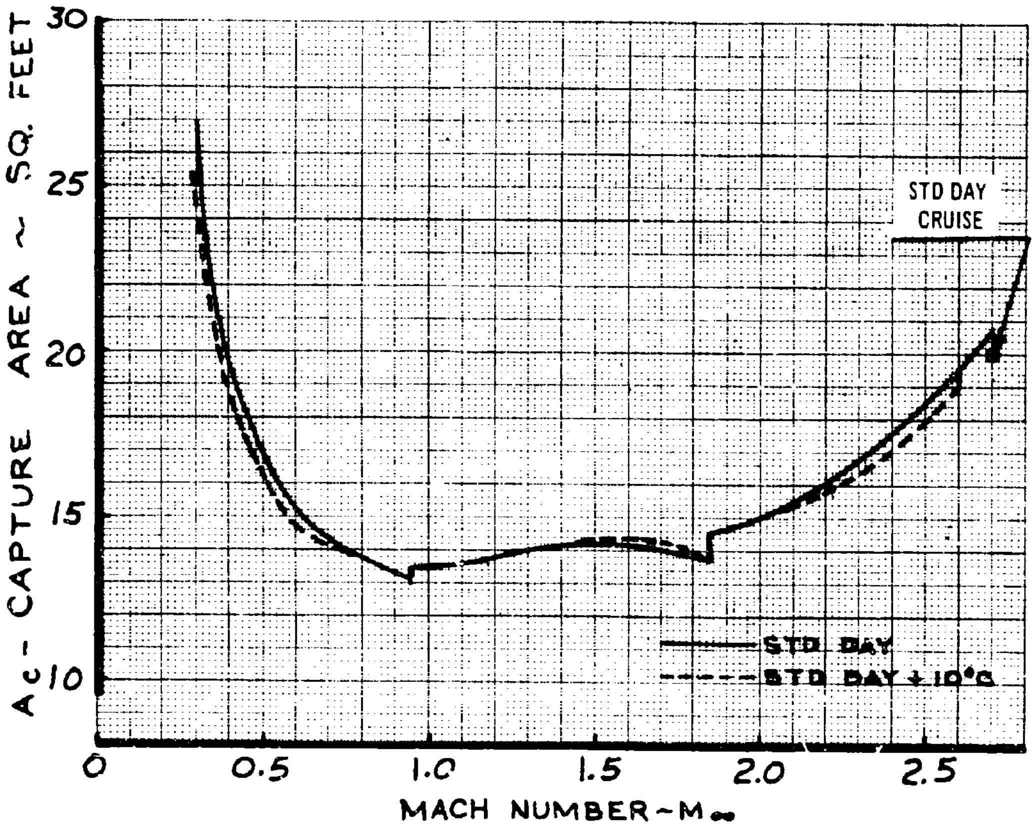


*Figure S II 20. Freestream Capture Area, Climb and Acceleration, Standard Day + 10°C*

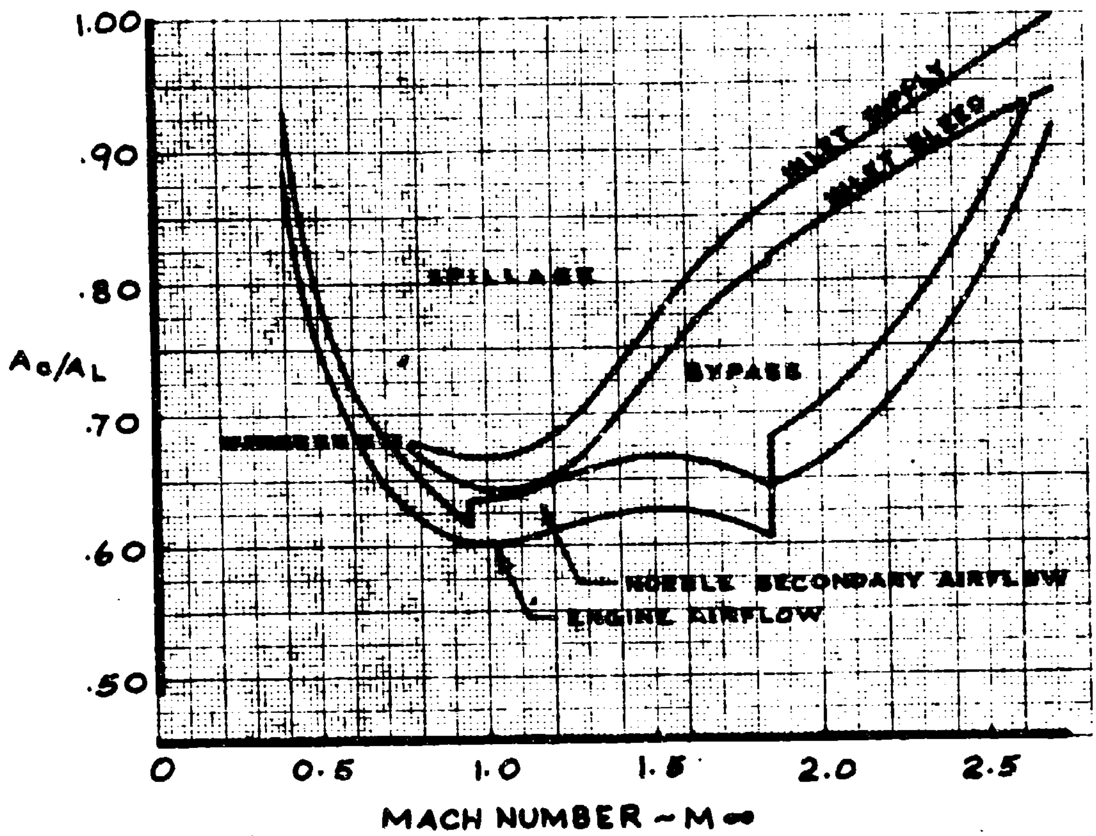


*Figure S11-21a. Inlet Supply/Engine Demand Area Ratio, Climb and Acceleration, Standard Day*

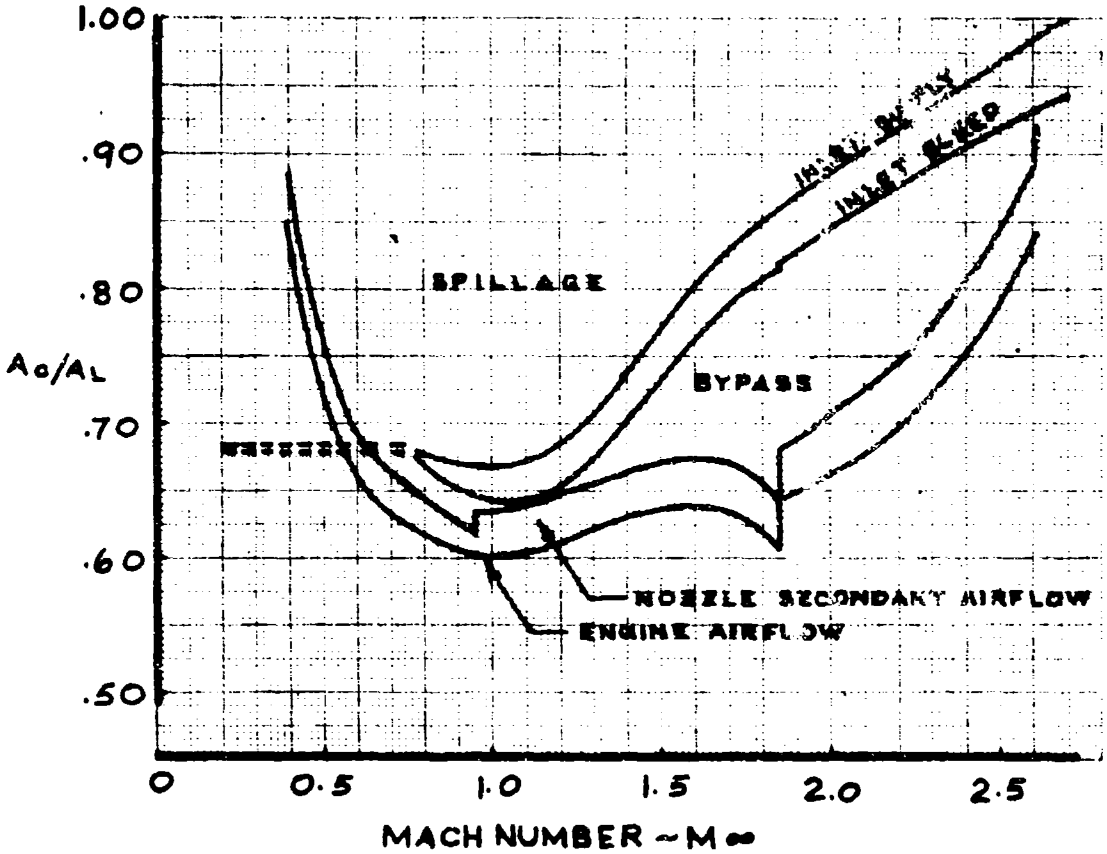


*Figure S11-21b. Inlet Supply/Engine Demand Area Ratio, Climb and Acceleration, Standard Day + 10°C*

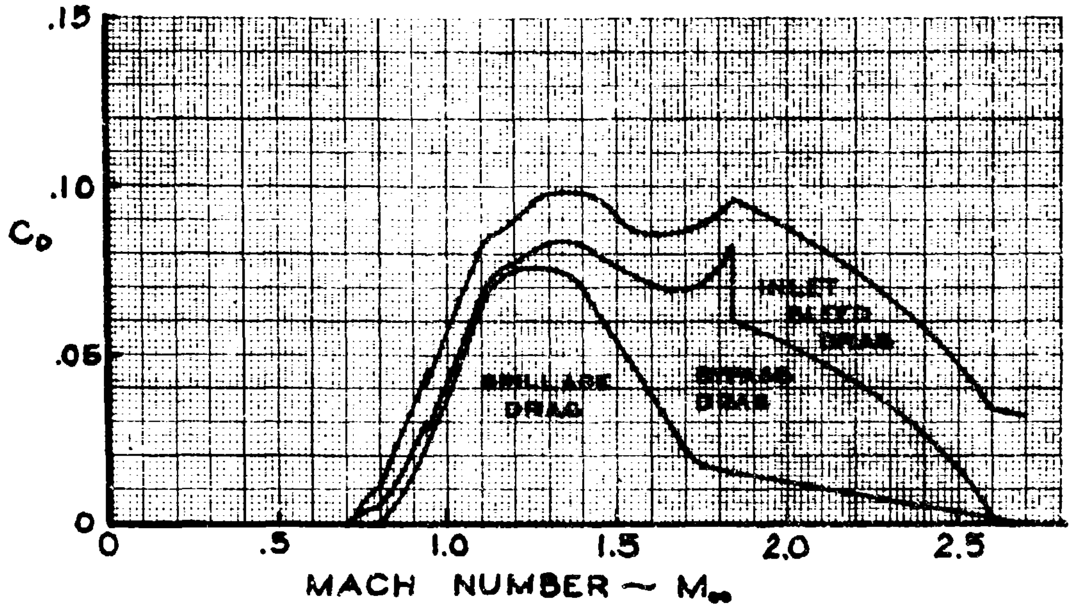


*Figure S II–23. Inlet Installed Drag Coefficient, Climb and Acceleration, Standard Day*

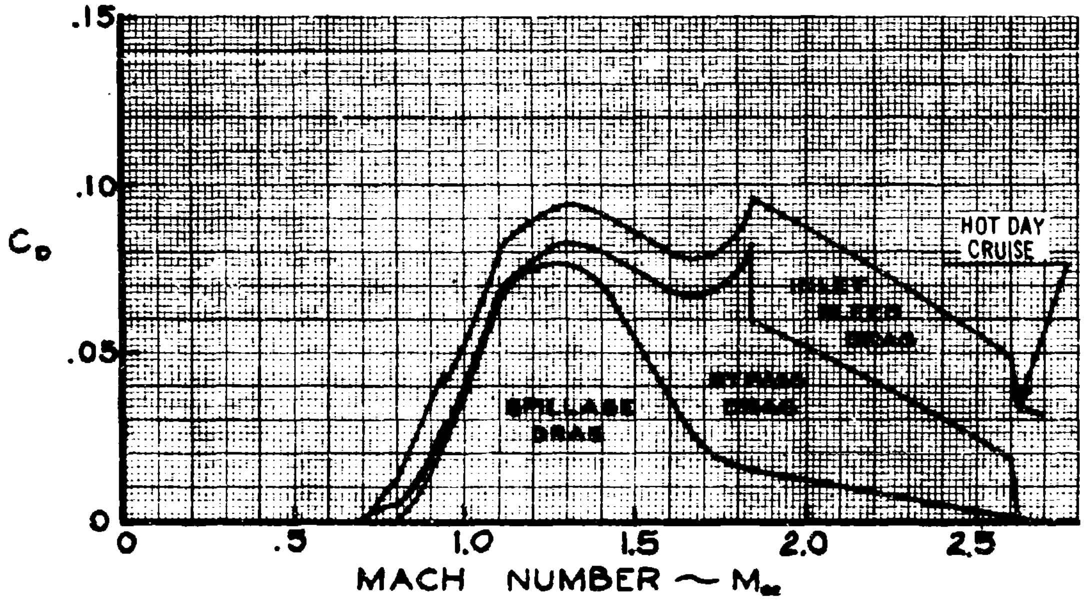


*Figure SII–24. Inlet Installed Drag Coefficient, Climb and Acceleration – Standard Day + 10°C*