AE 460

PROPULSION SYSTEM DATA

FOR

CLOSE AIR SUPPORT

(CAS)

AIRCRAFT

F 91

CONCEPTUAL TURBOFAN ENGINE

September 2002

FALL 1991 STUDENT DESIGN ENGINE DATA

The engine data supplied represents an advanced technology mixed flow turbofan with an Initial Operational Capability (IOC) date of 2000. The engine cycle has a design bypass ratio of 1.8, a design overall pressure ratio of 27 and a design airflow size of 210 lbs/sec.

Installation and Weight Data

The installation and weight data are supplied for the engine. Included are engine and exhaust nozzle outline dimensions and weights. Performance data is for the base size engine (210 lbs/sec). Dimensions for scale factors of 83.3% (175 lb/sec) and 120% (252 lb/sec) are provided.

$$\left(\frac{\text{Airflow 1}}{\text{Airflow 2}}\right)^{n} = \left(\frac{\text{Weight 1}}{\text{Weight 2}}\right) \text{ or } = \left(\frac{\text{Length 1}}{\text{Length 2}}\right)$$

The proper scaling exponents, n, weight and dimensions are provided on the engine weight and dimension chart.

Engine Performance Data

For each Mach/Altitude point the performance data include:

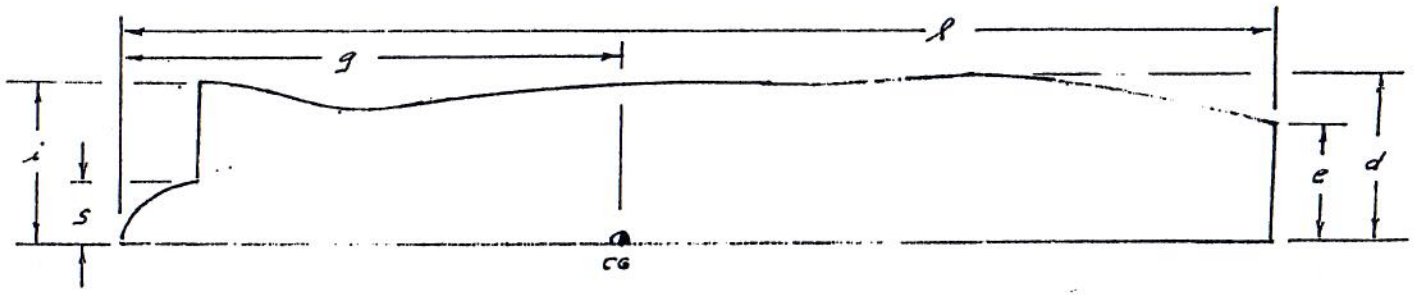
Aircraft Mach Number
Altitude in feet
Physical Net Thrust in pounds
Physical Fuel Flow in lbs/hr or Thrust Specific Fuel Consumption

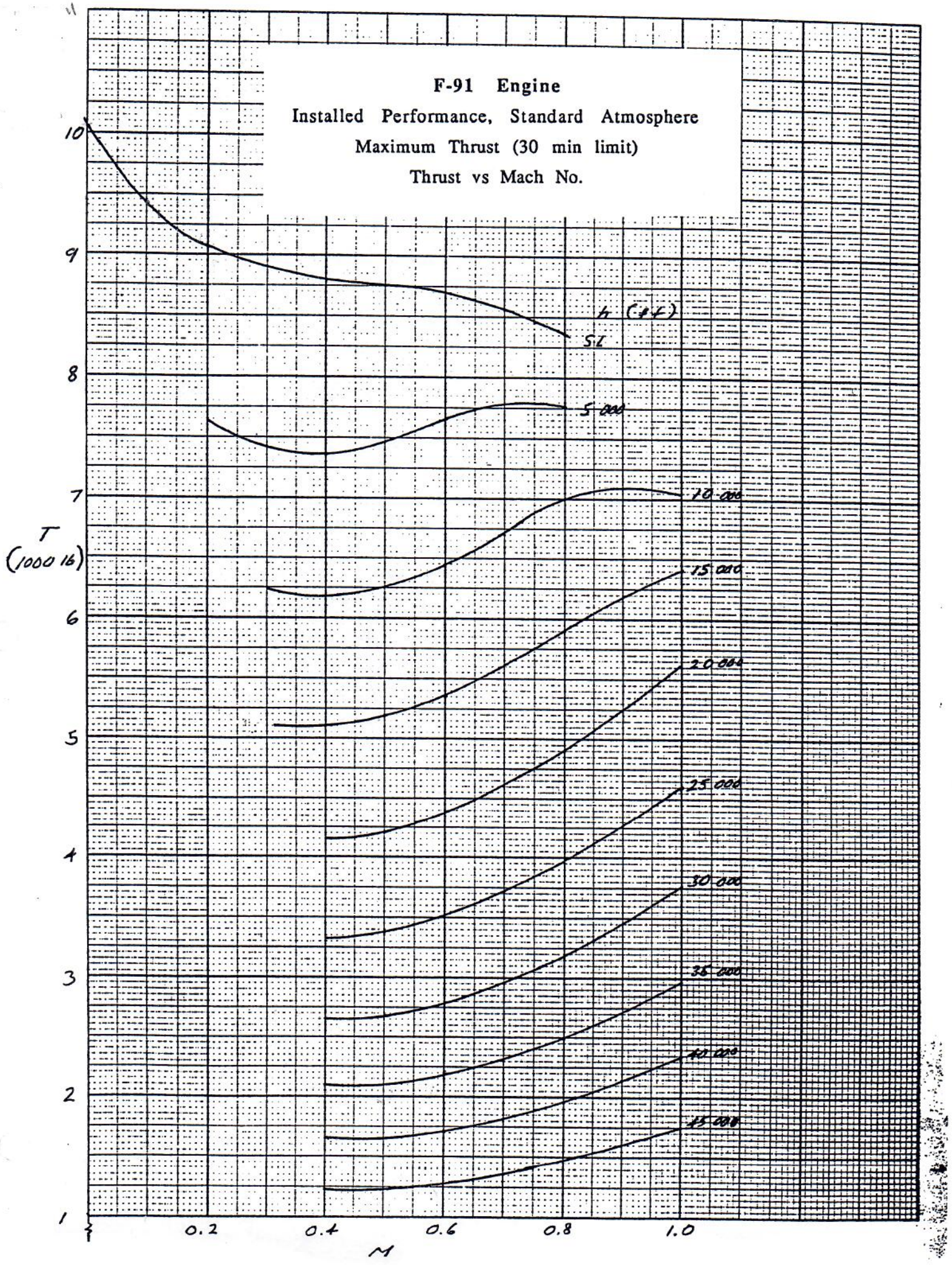
The performance data includes typical installation losses, including bleed and power extraction, so no corrections are required.

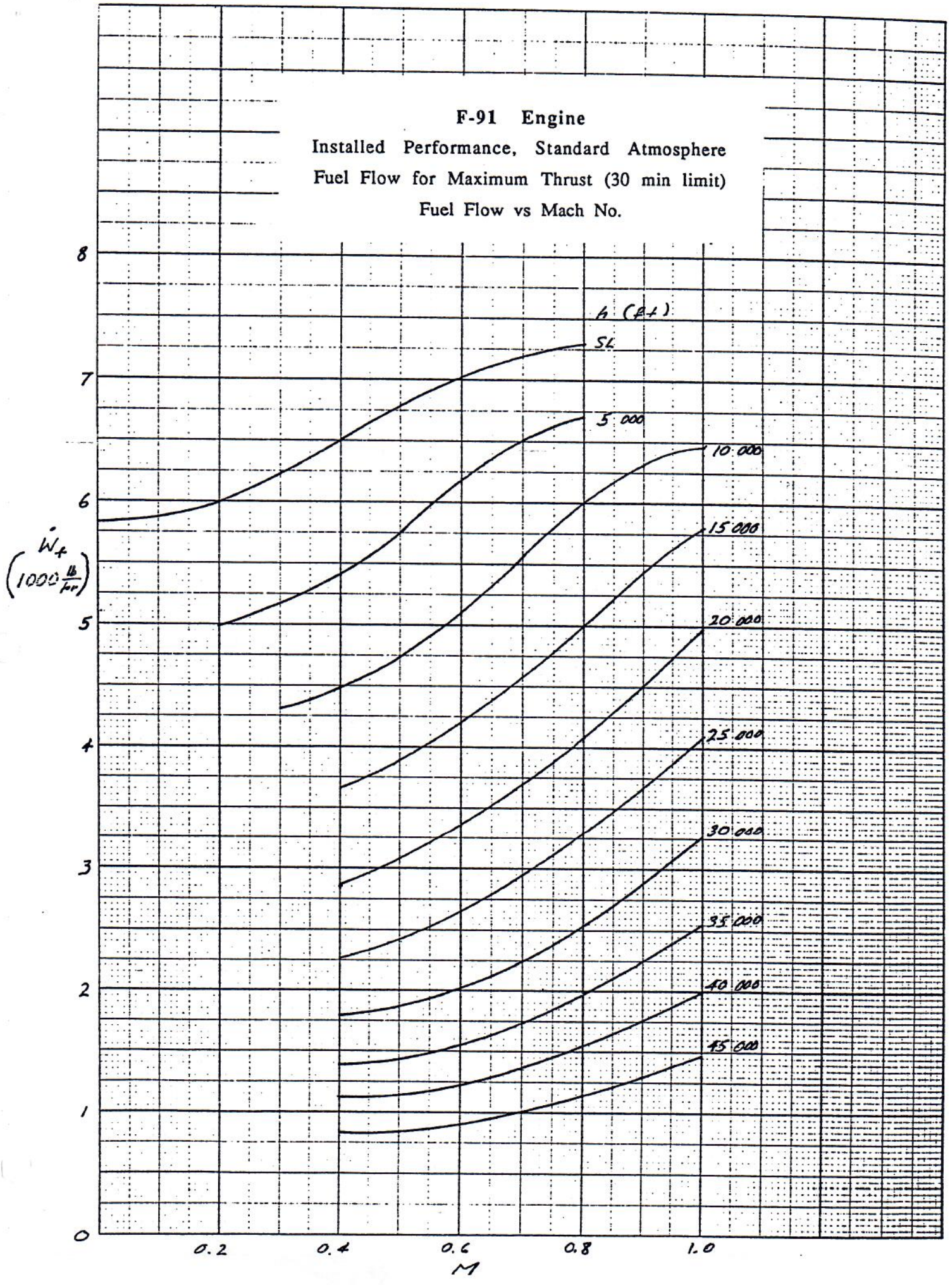
The performance data are for the 210 lb/sec engine. For other size engines thrust and fuel flow would vary linearly with design airflow.

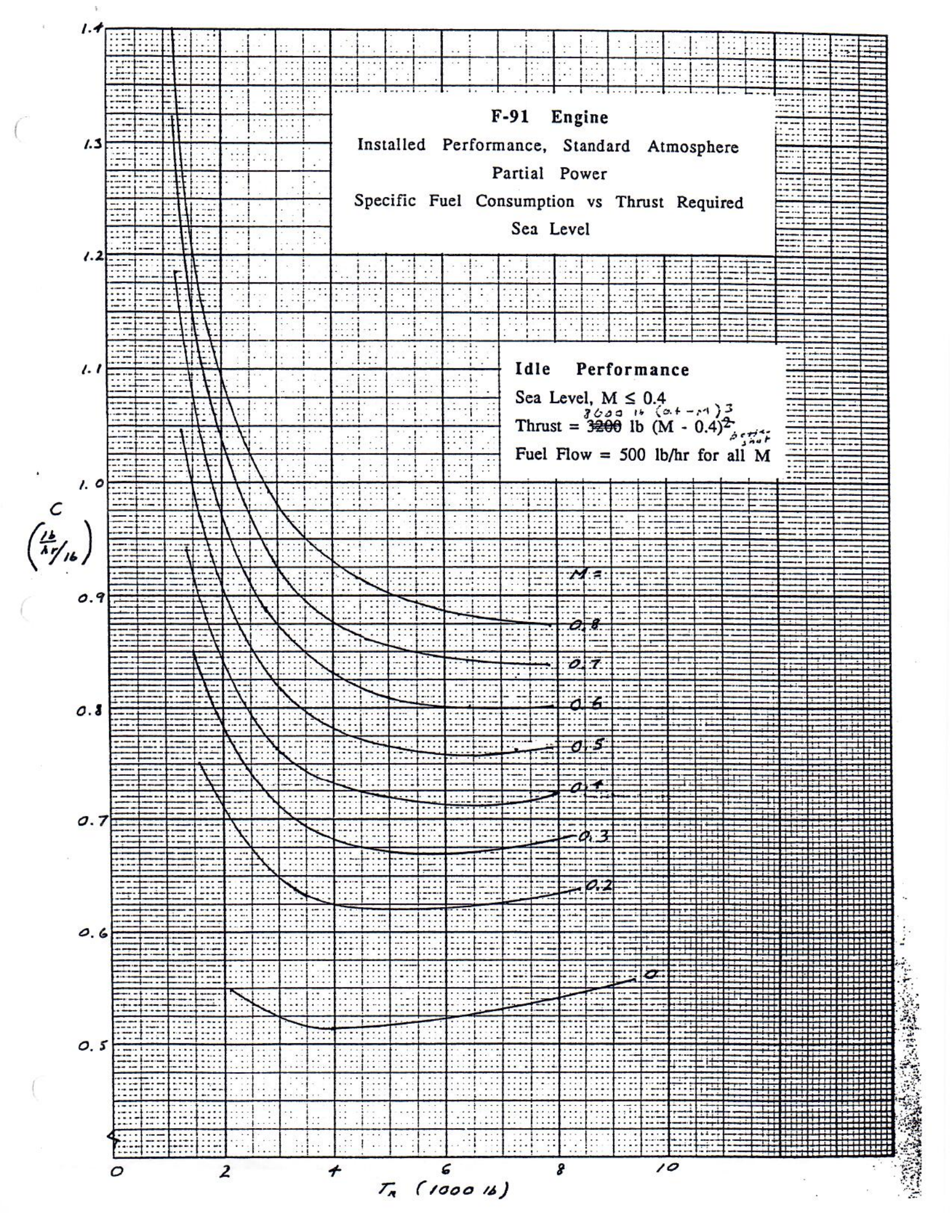
F-91 Engine

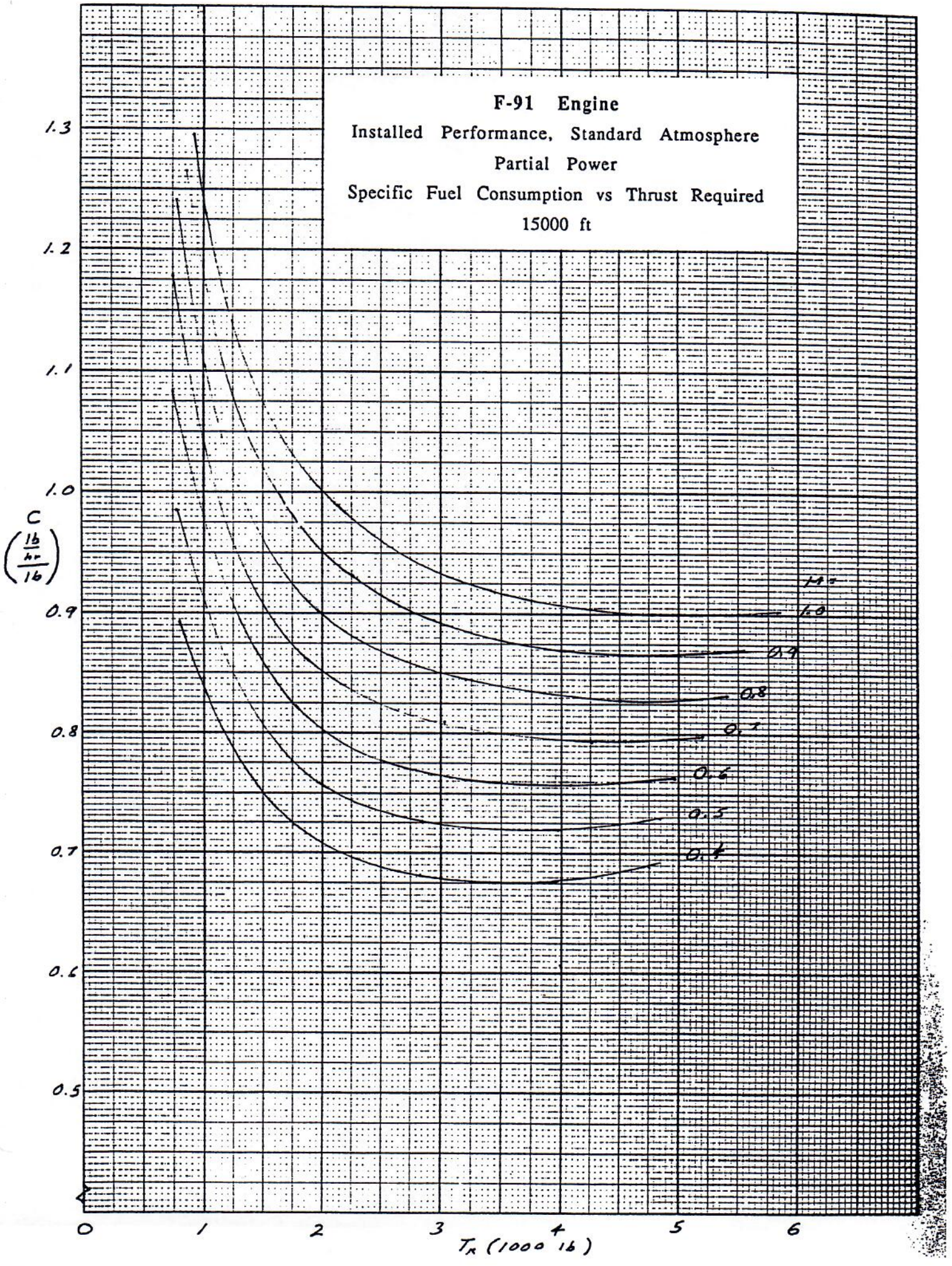
		n			
Air Flow (lb/sec)			175	210	252
Weight (lb)		0.9	2089	2462	2901
Dimensions (in)	ℓ	0.4	120.0	129.1	138.8
	g	0.4	74.4	80.0	86.1
	i	0.5	16.3	17.9	19.6
	s	0.5	6.6	7.2	7.9
	e	0.5	12.2	13.4	14.6
	d	0.5	18.2	19.9	21.8

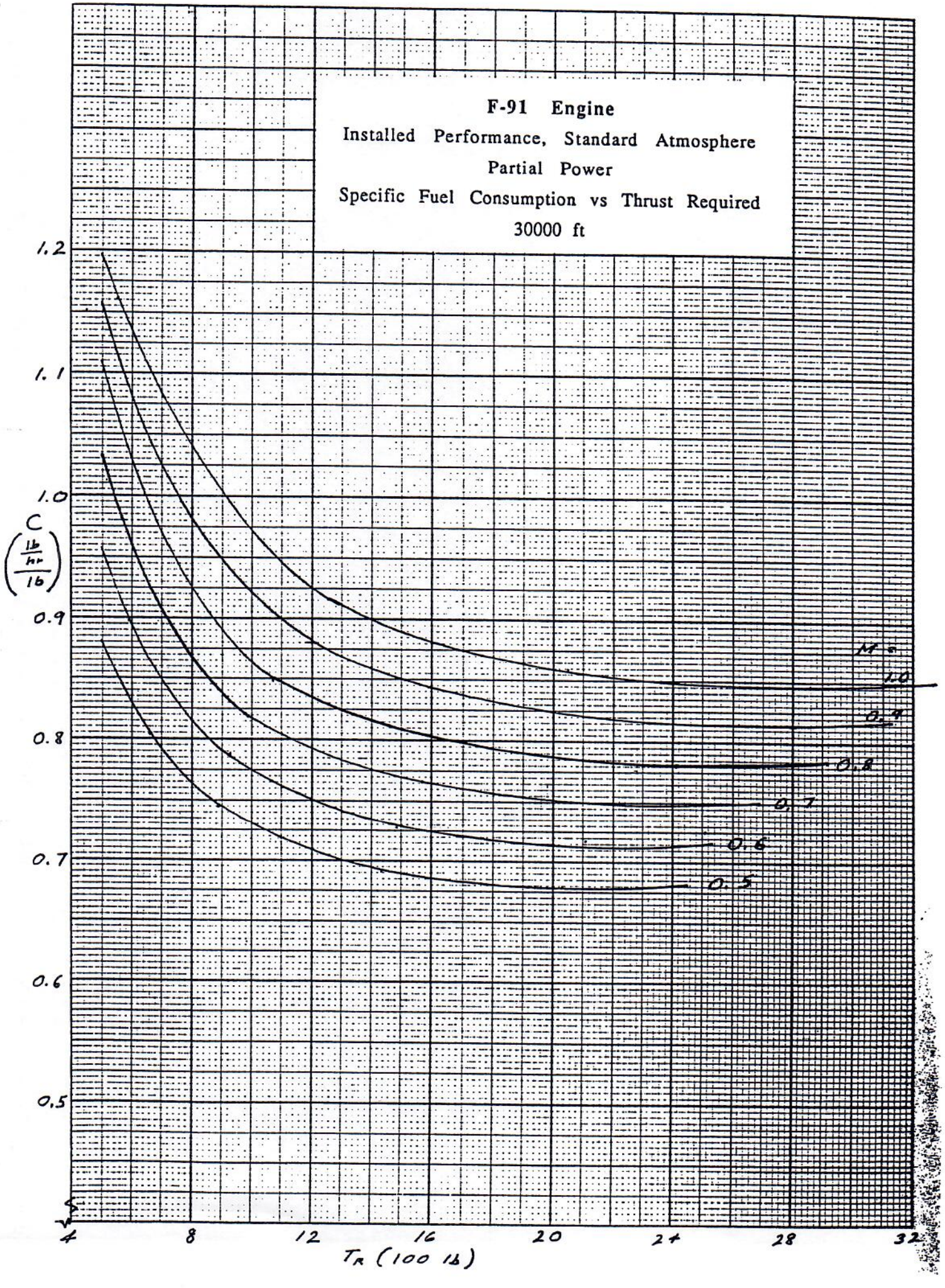


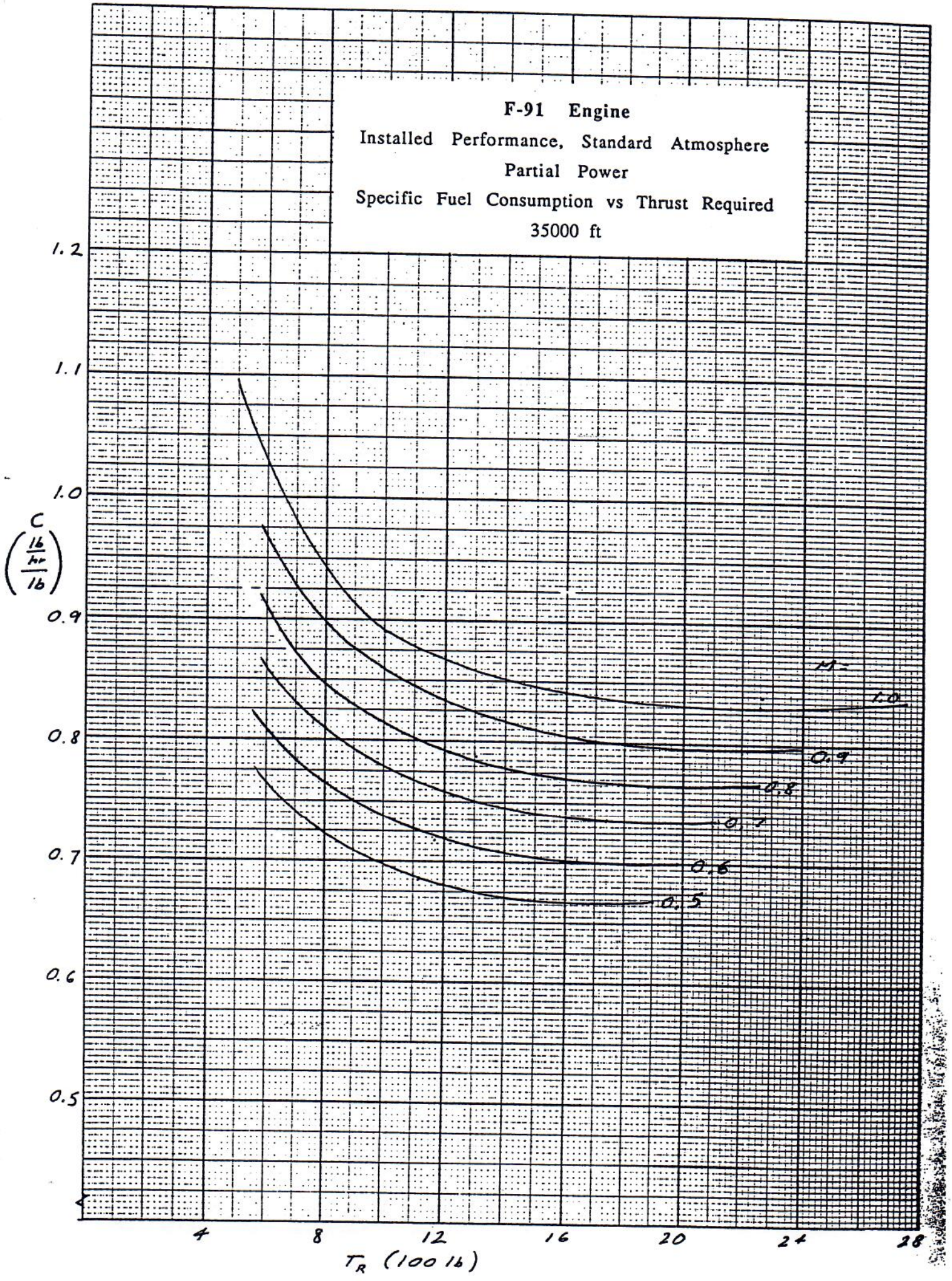

F-91 Engine
Installed Performance, Standard Atmosphere
Maximum Thrust (30 min limit)
Thrust vs Mach No.
h (ft)
SL
5 000
10 000
15 000
20 000
25 000
30 000
35 000
40 000
45 000
T (1000 lb)
M
0.2
0.4
0.6
0.8
1.0
1
2
3
4
5
6
7
8
9
10

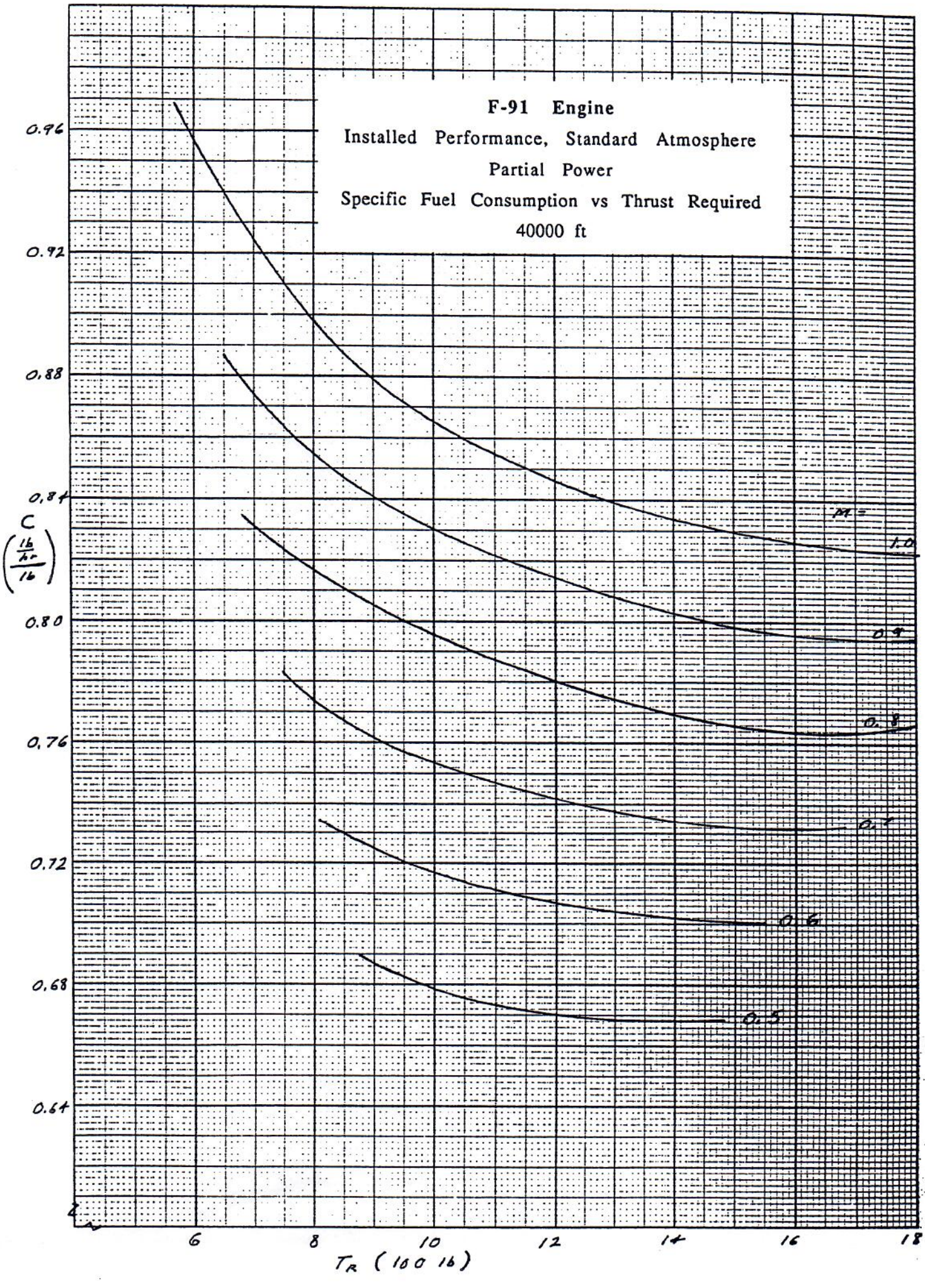

F-91 Engine
Installed Performance, Standard Atmosphere
Fuel Flow for Maximum Thrust (30 min limit)
Fuel Flow vs Mach No.
h (ft)
SL
5 000
10 000
15 000
20 000
25 000
30 000
35 000
40 000
45 000
$\dot{W}_f$ (1000 lb/hr)
M
0
1
2
3
4
5
6
7
8
0.2
0.4
0.6
0.8
1.0

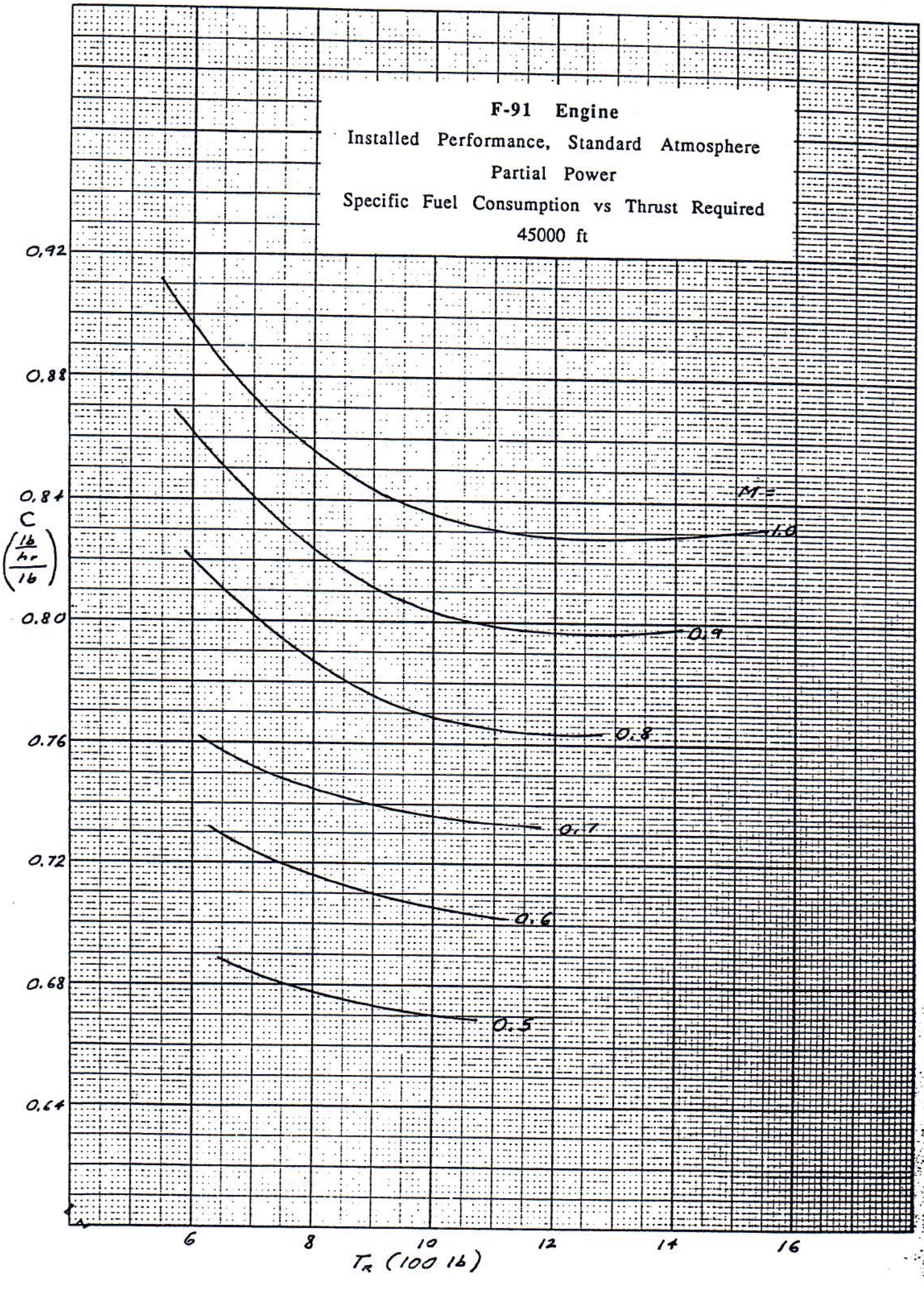

F-91 Engine
Installed Performance, Standard Atmosphere
Partial Power
Specific Fuel Consumption vs Thrust Required
Sea Level
Idle Performance
Sea Level, M ≤ 0.4
Thrust = 3200 lb (M - 0.4)²
Fuel Flow = 500 lb/hr for all M
C (lb/hr/lb)
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
M =
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0
2
4
6
8
10
T_R (1000 lb)


F-91 Engine
Installed Performance, Standard Atmosphere
Partial Power
Specific Fuel Consumption vs Thrust Required
15000 ft
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
C
(lb/hr/lb)
M=
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0
1
2
3
4
5
6
T_R (1000 lb)


F-91 Engine
Installed Performance, Standard Atmosphere
Partial Power
Specific Fuel Consumption vs Thrust Required
30000 ft
1.2
1.1
1.0
C
(lb/hr / lb)
0.9
0.8
0.7
0.6
0.5
M =
1.0
0.9
0.8
0.7
0.6
0.5
4
8
12
16
20
24
28
32
T_R (100 lb)


F-91 Engine
Installed Performance, Standard Atmosphere
Partial Power
Specific Fuel Consumption vs Thrust Required
35000 ft
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
C (lb/hr/lb)
M=
1.0
0.9
0.8
0.7
0.6
0.5
4
8
12
16
20
24
28
T_R (100 lb)


F-91 Engine
Installed Performance, Standard Atmosphere
Partial Power
Specific Fuel Consumption vs Thrust Required
40000 ft
0.96
0.92
0.88
0.84
0.80
0.76
0.72
0.68
0.64
C
(lb/hr / lb)
M =
1.0
0.9
0.8
0.7
0.6
0.5
6
8
10
12
14
16
18
T_R (100 lb)


F-91 Engine
Installed Performance, Standard Atmosphere
Partial Power
Specific Fuel Consumption vs Thrust Required
45000 ft
0.92
0.88
0.84
0.80
0.76
0.72
0.68
0.64
C
(lb/hr/lb)
M =
1.0
0.9
0.8
0.7
0.6
0.5
6
8
10
12
14
16
T_R (100 lb)

Radar antenna 2' diameter

74 hard points OK

Errata ~~700 lb~~ landing reserve + 300 lb, $n = 7.33$ vs 7.50

Trim volumes: $V_H \geq 0.4$, $V_V \geq 0.06$

q_{max} = 1000 lb/ft²

1 gal = ~~4 lb~~ 6.55 lb, JP-4

Any combination (symmetric) of external tanks for FC.

No external tanks for WC#.

Wt distributions:

Gear 25% + 2(37.5%)

Surfaces + Hydraulics

Rudder	10
Horiz	25
Ailerons	25
Flaps	40

} of

Drag

Protuberances $f = 0.5$ ft², including gun.

Interference, clean 5% increment

Bombs Rack = 1 bomb, 6 bombs = 5 front bombs

External - Bombs, WCR, Add Σf (0.1) for tanks

Performance

(500 lb for Start, Taxi, TO, Accelerate) OK

Drag

Tanks - Interference + protuberances = 10% (tank + pylon)

With slats out, spoilers out, flaps down -
Use ΔC_D for trim all, C_L for clean wing.

Flaps, Slats

$$\Delta C_{L_{MAX}}, \text{Slats} = \Delta C_{L_{MAX}} \left(1 - \frac{\delta f}{G}\right)$$

Plain flap	$\Rightarrow$	$G = 80°$
S. S		100°
Double slot		140°

Inlet area = 1.2 (exhaust area) = 0.833 (comp. face, less spinner)

Gun Size (incl' can)

OPTION — IAW (Scale) Picture, $\ell = ((348.5 - 124.0) \cdot \text{in}) + \text{Extreme Unit}$

OR Roskam IV $= 15'$

Canopy drag

$$f = S_{exp} \left(\frac{2}{\left(\frac{\ell}{h}\right)^2} + 5 \cdot 10^{-4} \left(\frac{\ell}{h}\right)^2 \right)$$

When Skin friction drag is omitted, must be included with fuselage

h = Δ beyond streamlined shape

Spoilers

In front of flap

Use { spoiler drag R IV / flap drag as it was

Delete flap lift

Split flaps — Deflections

Use D: Split flaps

$\Delta = 0$

$$k_{L_0} \quad k_{L_0} = k' + k'' \left(1 - \frac{C_{L_{MIN}}}{C_{L_B}}\right)^2$$