

# ESTES INDUSTRIES TECHNICAL NOTE TN-1

## MODEL ROCKET ENGINES

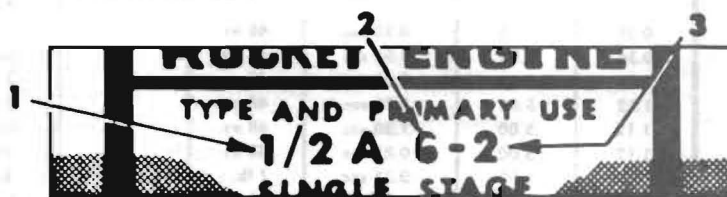
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**ESTES INDUSTRIES**  
 BOX 227, PENROSE, COLO. 81240

### ENGINE TYPES & CLASSIFICATION



All engines sold by Estes Industries are stamped with a code designation which, when understood, will give the rocketeer important and useful data on the engine's performance capabilities. Here's how to read this coding: (refer to engine illustration above).

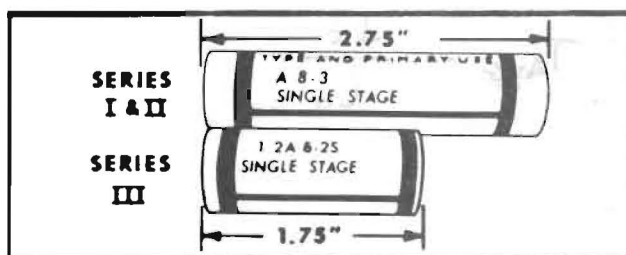
1. This portion indicates the "total impulse" or total power produced by the engine as shown in the chart below.
2. This portion is the engine's average thrust in newtons (1 newton equals 0.224 pounds). For normal flying an average thrust of 3 to 7 newtons is recommended (Series I and III). For lifting large payloads and for high acceleration studies high thrust (Series II) engines are recommended.
3. This number gives the delay in seconds between burnout and ejection charge activation. Engines with "-0" have no delay charge, no ejection charge, and are for use in booster stages only.

**Series III engines are identical in performance to the corresponding Series I engines. Series III engines are identified by the final "S" in their code.**

The label color of all Estes engines indicates the recommended use of the engine. Green engines are for use in single stage models. Purple engines are for use in the top stage of a multi-stage rocket. Red engines are for use in all booster and intermediate stages of multi stage models.

### TOTAL IMPULSE CLASSIFICATION

Code	Pound-Seconds	Newton-Seconds
1/4A	0.00 — 0.14	0.00 — 0.625
1/2A	0.14 — 0.28	0.625 — 1.25
A	0.28 — 0.56	1.25 — 2.50
B	0.56 — 1.12	2.50 — 5.00
C	1.12 — 2.24	5.00 — 10.00



# ROCKET ENGINE TYPES AND CLASSIFICATION

$$I_t = m v = \frac{W v}{g}$$

$$(2.24 \text{ lb} \cdot \text{sec})(32.2 \text{ ft/sec}^2)$$

$$v = \frac{I_t g}{W_P}$$

0.2748 lb

2625 fps

Cat. No. and Engine Type	Total Impulse		Thrust Duration	Maximum Thrust	Thrust Curve 3	Time Delay (+15%)	Engine Length	Initial Weight	Propellant Weight	Label Color	Maximum Lift-off Weight <sup>4</sup>
	lb-sec. 1	n-sec. 2									
<b>SINGLE STAGE ENGINES</b>											
1/4 A3-1	0.14	0.625	0.24 sec	22 oz.	1	1 sec	2.75 in.	0.48 oz.	0.00172 lb.	Green	1.5 oz.
1/4 A3-15**	0.14	0.625	0.24 sec	22 oz.	1	1 sec	1.75 in.	0.36 oz.	0.00172 lb.	Green	1.5 oz.
1/4 A3-2	0.14	0.625	0.24 sec	22 oz.	1	2 sec	2.75 in.	0.50 oz.	0.00172 lb.	Green	1.0 oz.
1/4 A3-25**	0.14	0.625	0.24 sec	22 oz.	1	2 sec	1.75 in.	0.38 oz.	0.00172 lb.	Green	1.0 oz.
1/2 A6-2	0.28	1.25	0.20 sec	46 oz.	2	2 sec	2.75 in.	0.53 oz.	0.00344 lb.	Green	2.5 oz.
1/2 A6-25**	0.28	1.25	0.20 sec	46 oz.	2	2 sec	1.75 in.	0.41 oz.	0.00344 lb.	Green	2.5 oz.
A5-2	0.56	2.50	0.50 sec	46 oz.	3	2 sec	2.75 in.	0.59 oz.	0.00687 lb.	Green	3.0 oz.
A8-3	0.56	2.50	0.42 sec	48 oz.	4	3 sec	2.75 in.	0.57 oz.	0.00918 lb.	Green	4.0 oz.
B4-2	1.12	5.00	1.20 sec	48 oz.	5	2 sec	2.75 in.	0.70 oz.	0.01836 lb.	Green	4.0 oz.
B4-4	1.12	5.00	1.20 sec	48 oz.	5	4 sec	2.75 in.	0.74 oz.	0.01836 lb.	Green	3.5 oz.
B6-4	1.12	5.00	0.83 sec	48 oz.	6	4 sec	2.75 in.	0.67 oz.	0.01374 lb.	Green	4.5 oz.
B14-5*	1.12	5.00	0.35 sec	7 lb.	8	5 sec	2.75 in.	0.69 oz.	0.01374 lb.	Green	5.0 oz.
C6-5	2.24	10.00	1.70 sec	48 oz.	7	5 sec	2.75 in.	0.91 oz.	0.02748 lb.	Green	4.0 oz.
<b>UPPER STAGE ENGINES (OR SINGLE STAGE ENGINES IF USED IN VERY LIGHT ROCKETS)</b>											
1/4 A3-4	0.14	0.625	0.24 sec	22 oz.	1	4 sec	2.75 in.	0.51 oz.	0.00172 lb.	Purple	.75 oz.
1/4 A3-45**	0.14	0.625	0.24 sec	22 oz.	1	4 sec	1.75 in.	0.39 oz.	0.00172 lb.	Purple	.75 oz.
1/2 A6-4	0.28	1.25	0.20 sec	46 oz.	2	4 sec	2.75 in.	0.54 oz.	0.00344 lb.	Purple	1.0 oz.
1/2 A6-45**	0.28	1.25	0.20 sec	46 oz.	2	4 sec	1.75 in.	0.42 oz.	0.00344 lb.	Purple	1.0 oz.
A5-4	0.56	2.50	0.50 sec	46 oz.	3	4 sec	2.75 in.	0.64 oz.	0.00687 lb.	Purple	1.5 oz.
A8-5	0.56	2.50	0.42 sec	48 oz.	4	5 sec	2.75 in.	0.62 oz.	0.00918 lb.	Purple	2.0 oz.
B4-6	1.12	5.00	1.20 sec	48 oz.	5	6 sec	2.75 in.	0.78 oz.	0.01836 lb.	Purple	1.5 oz.
B6-6	1.12	5.00	0.83 sec	48 oz.	6	6 sec	2.75 in.	0.71 oz.	0.01374 lb.	Purple	2.0 oz.
B14-6*	1.12	5.00	0.35 sec	7 lb.	8	6 sec	2.75 in.	0.71 oz.	0.01374 lb.	Purple	2.5 oz.
B14-7*	1.12	5.00	0.35 sec	7 lb.	8	7 sec	2.75 in.	0.73 oz.	0.01374 lb.	Purple	3.5 oz.
C6-7	2.24	10.00	1.70 sec	48 oz.	7	7 sec	2.75 in.	0.95 oz.	0.02748 lb.	Purple	2.5 oz.
<b>BOOSTER ENGINES</b>											
1/2 A6-0	0.28	1.25	0.18 sec	46 oz.	2	none	2.75 in.	0.48 oz.	0.00344 lb.	Red	4.0 oz.
1/2 A6-05**	0.28	1.25	0.18 sec	46 oz.	2	none	1.75 in.	0.36 oz.	0.00344 lb.	Red	4.0 oz.
A8-0	0.56	2.50	0.40 sec	48 oz.	4	none	2.75 in.	0.51 oz.	0.00918 lb.	Red	4.0 oz.
B6-0	1.12	5.00	0.80 sec	48 oz.	6	none	2.75 in.	0.58 oz.	0.01374 lb.	Red	4.0 oz.
B14-0*	1.12	5.00	0.35 sec	7 lb.	8	none	2.75 in.	0.61 oz.	0.01566 lb.	Red	6.0 oz.
C6-0	2.24	10.00	1.68 sec	48 oz.	7	none	2.75 in.	0.80 oz.	0.02748 lb.	Red	4.0 oz.
<b>STATIC TEST ENGINE</b>											
B4-0(P) 5	1.12	5.00	1.20 sec	48 oz.	5	none	2.75 in.	0.69 oz.	0.01836 lb.	Black	Don't Fly It! <sup>7</sup>

D-12 4.48 20.00 1.70 144 2.75 0.5494 lb

NOTES: \*Series II engine. \*\*Series III engine. <sup>1</sup>Pound-seconds. <sup>2</sup>Newton-seconds (figures shown are maximum - slight variations due to manufacturing tolerances will occur). <sup>3</sup>See pages 52 and 53. <sup>4</sup>With engines. <sup>5</sup>Static test engine with plug to prevent blow-through.

$$T_{AVG} = \frac{I_t}{t_b}$$

# ROCKET ENGINE DESIGN

The Series I and Series III engines are a solid propellant type with a dual thrust level design. There is a slight center bore at the very tip of the nozzle end of the propellant grain which serves two purposes. First it provides for easy ignition. Second, as you will note from thrust curves 5, 6 and 7, this special design produces a high initial thrust which accelerates the rocket to a suitable flying speed quickly. This is because the slight center bore provides a relatively large burning area, resulting in faster consumption of the fuel.

After this initial high thrust, a transition to an end burning grain is made and the thrust drops to a sustaining level (except on low total impulse engines which burn out by this time). Data from wind tunnel tests shows this dual thrust level to be the most effective design for rocket engines which are used to propel lightweight model rockets at sub-sonic speeds.

The slow-burning delay and tracking charge is ignited at the burnout of the propellant grain. This slow-burning, smoke-producing charge provides no thrust, but permits the rocket to coast upward to its peak altitude. At the burnout of the delay charge a recovery system ejection charge is ignited which pressurizes the forward end of the rocket body tube, activating the recovery system. For further information, see the performance graphs and cutaway drawings.

The Series II engine is a solid propellant type with a full center burning grain. This provides a greater propellant burning area, resulting in a higher thrust level than the Series I engines, but with a relatively short thrust duration. The total thrust duration of a Series II engine is slightly under 0.35 sec. This makes the thrust characteristics of the engine somewhat like a sledge hammer blow—thrust rises to over 7 pounds in a fraction of a second, then drops off again, as shown in the Series II engine performance graph. The average thrust of the Series II engine is 3.1 pounds (14 newtons). The result is that the Series II engine is ideal for high acceleration studies, as a booster on heavy multi-stage rockets, and for drag racing. Delay charge and ejection charge operation are the same in all series of engines.

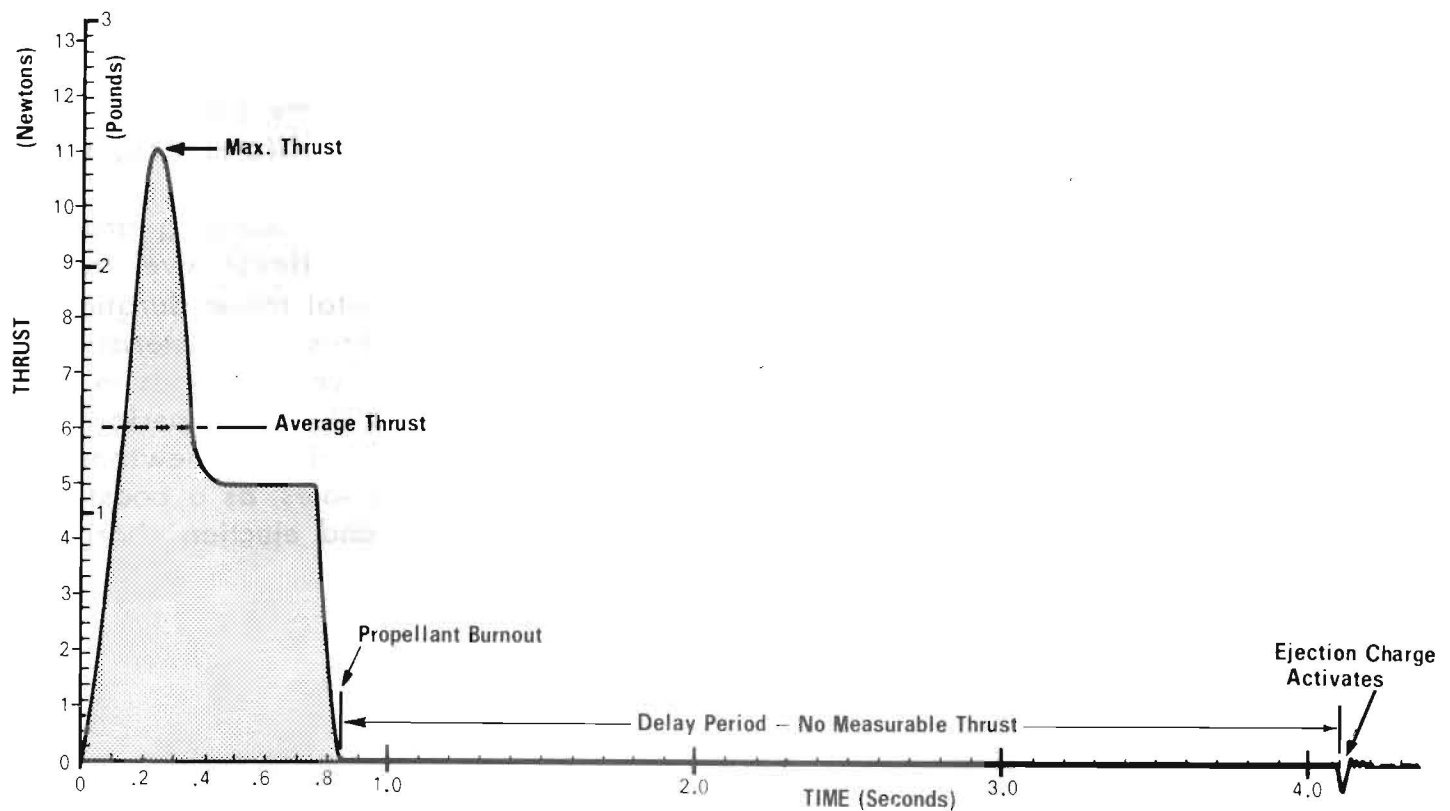
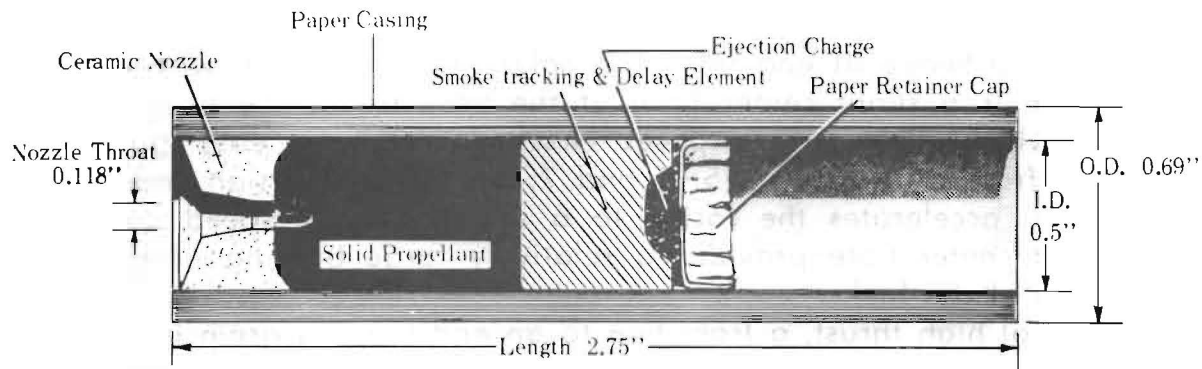


# Typical time-thrust curve

## B6-4 Series I

Specific Impulse – 80-83 Lb-Sec. per Lb.

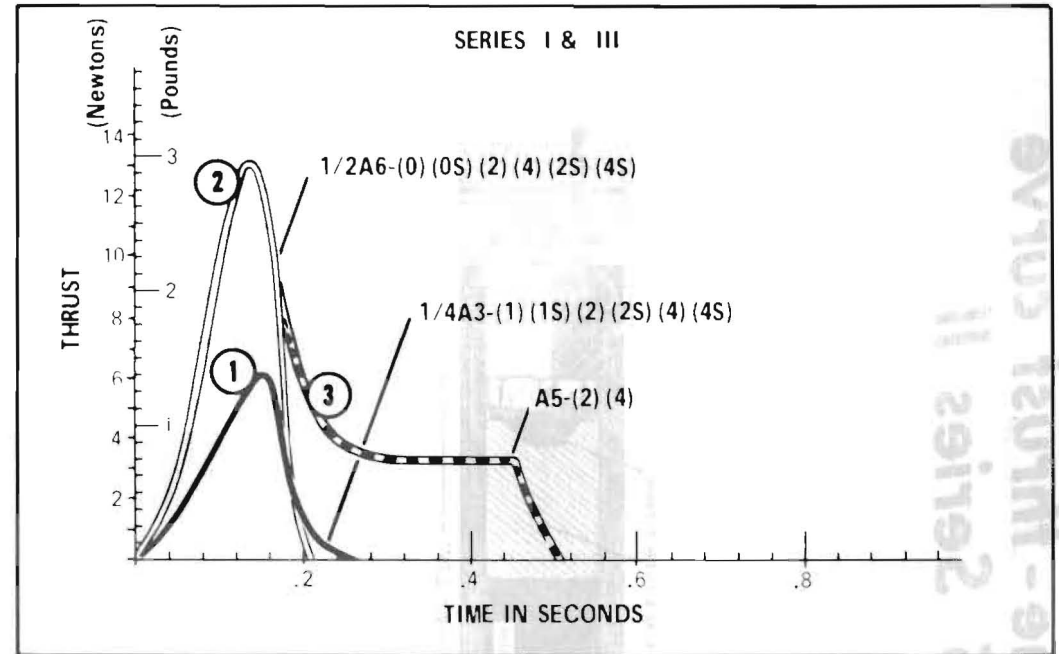
Exhaust Velocity – 2550-2650 Ft/Sec.



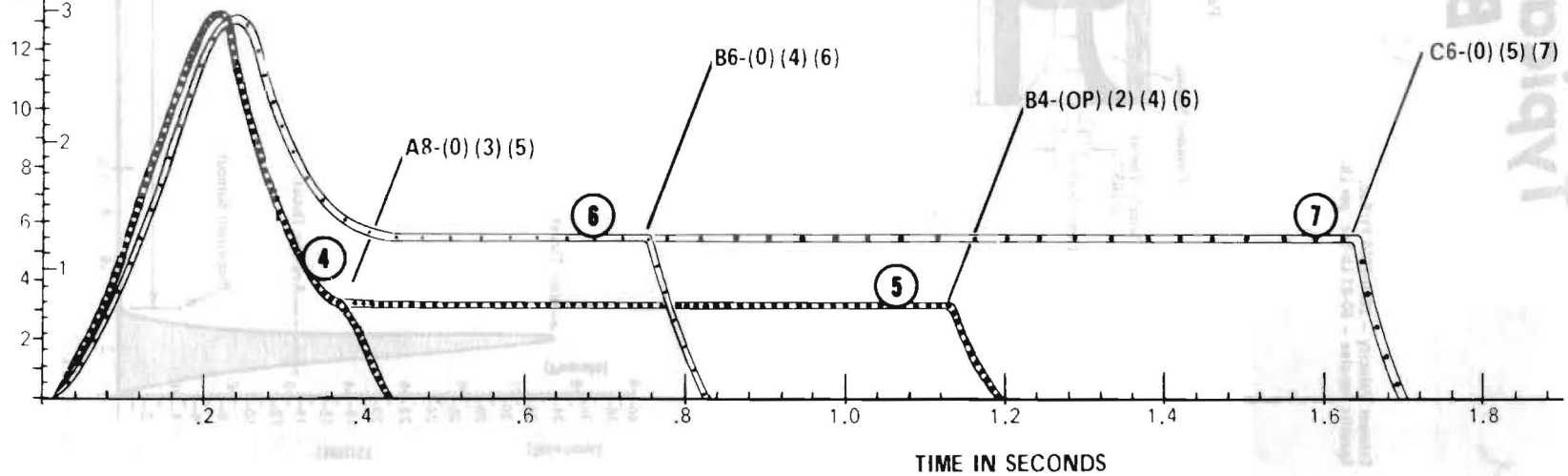
# ESTES SERIES I AND SERIES III ENGINES

Circled numbers refer to thrust-curve column in engine selection chart

THRUST IN NEWTONS  
THRUST IN POUNDS

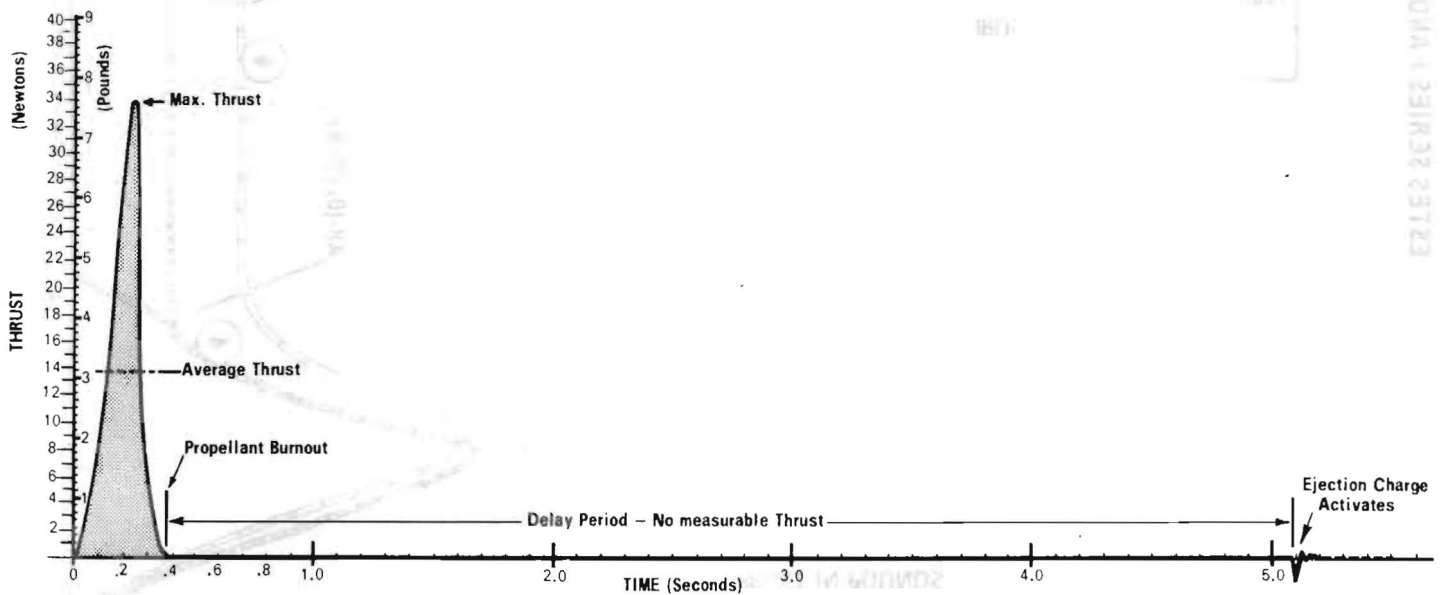
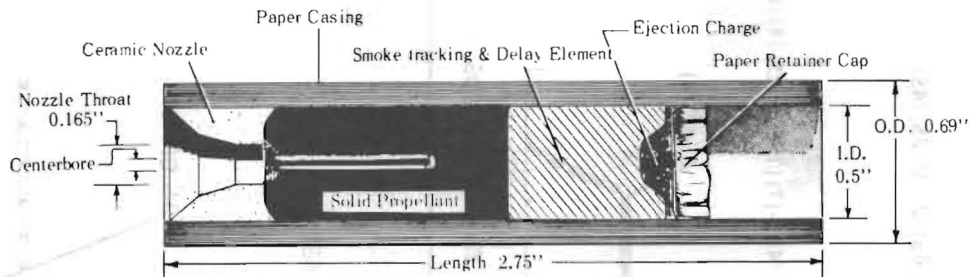


## SERIES I



# Typical time - thrust curve B14-5 Series II

Exhaust Velocity - 2550-2650 Ft./Sec.  
Specific Impulse - 80-83 Lb.-Sec. per Lb.



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