Casing Justification Report for 1-Grain KNSB Solid Rocket Motor test

Wamburu Ndirangu
Solid Propulsion Team

June 30, 2025

1. Introduction

This report provides a detailed justification for the use of an aluminum 6063-T5 motor casing with an inner diameter of 94 mm, a wall thickness of 3 mm, and a length of 247 mm. The casing is designed for a 1-grain KNSB (65:35) solid rocket motor. Simulated chamber pressure was obtained from OpenMotor and SRM.XLS tools, with a peak steady-state operating pressure of 1 MPa. A safety factor of 1.5 is applied in accordance with standard engineering practice.

2. Material Properties

The selected material is **Aluminum 6063-T5**, chosen for its high strength-to-weight ratio and availability. Its mechanical properties are summarized below:

Property	**Value**
Yield Strength (σ_{yp})	110 MPa
Ultimate Tensile Strength (σ_{uts})	150 MPa
Young's Modulus (E)	70 000 MPa
Poisson's Ratio (μ)	0.33

Parameter	Value
Inner Diameter (d)	94 mm
Wall Thickness (t)	3 mm
Length (L)	247 mm
Operating Pressure (P_c)	1 MPa
Safety Factor (S_f)	1.5

3. Design Specifications

4. Structural Analysis

4.1 Minimum Required Wall Thickness

Using the thin-walled pressure vessel formula:

$$t_{\min} = \frac{P_c \cdot d \cdot S_f}{2 \cdot \sigma_{\text{yp}}} = \frac{1 \cdot 94 \cdot 1.5}{2 \cdot 110} = 0.6409\,\text{mm}$$

Selected thickness: $3\,\text{mm} > 0.64\,\text{mm} \Rightarrow$ **Safe**

4.2 Hoop Stress

$$\sigma_{\text{hoop}} = \frac{P_c \cdot d \cdot S_f}{2t} = \frac{1 \cdot 94 \cdot 1.5}{2 \cdot 3} = 23.5\,\text{MPa}$$

Within allowable limit of $110\,\text{MPa} \Rightarrow$ **Safe**

4.3 Axial Stress

$$\sigma_{\text{axial}} = \frac{P_c \cdot d \cdot S_f}{4t} = \frac{1 \cdot 94 \cdot 1.5}{4 \cdot 3} = 11.75\,\text{MPa}$$

Safe

4.4 Burst Pressure

$$P_{\text{burst}} = \frac{2 \cdot t \cdot \sigma_{\text{uts}}}{d} = \frac{2 \cdot 3 \cdot 150}{94} = 9.57\,\text{MPa}$$

Burst pressure is over 9 times the expected operating pressure $\Rightarrow$ **Safe**

5. Simulation Reference

The chamber pressure value of 1 MPa used in the above calculations was obtained from OpenMotor simulations and confirmed using SRM.XLS. These tools modeled the internal ballistics of a 1-grain BATES KNSB configuration and indicated that peak pressure would not exceed the specified value under nominal burn conditions.

5.1 OpenMotor Output

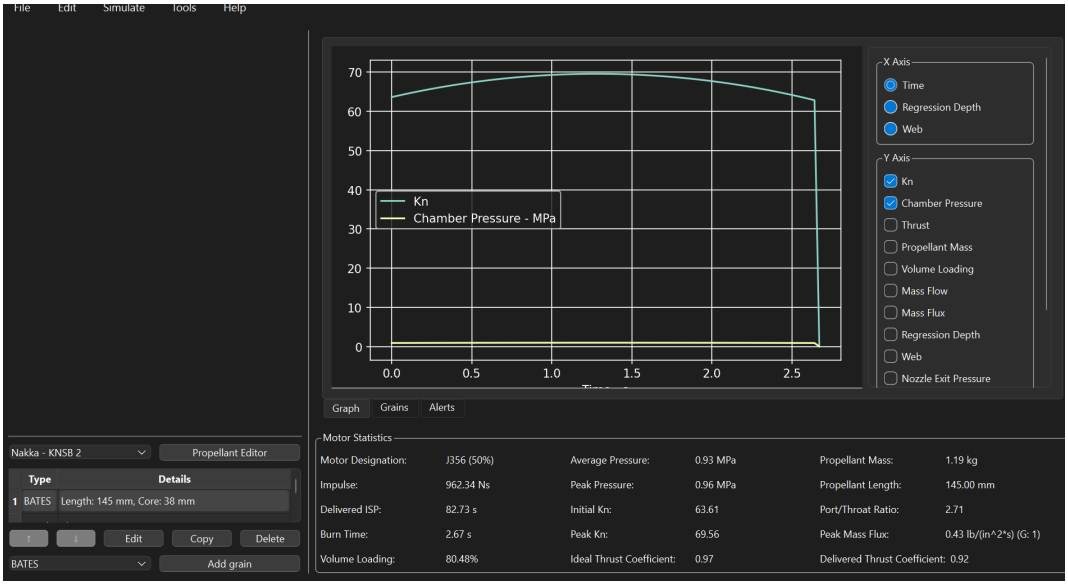

Figure 1: Chamber pressure vs. time curve generated from OpenMotor simulation for a 1-grain KNSB motor.

5.2 SRM.XLS Output

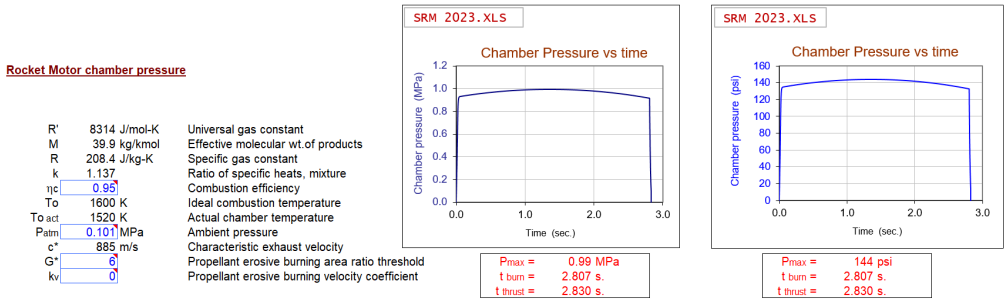

Figure 2: SRM.XLS spreadsheet output confirming simulated chamber pressure profile.

6. Conclusion

The use of a 3 mm thick aluminum 6063-T5 casing with a 94 mm internal diameter and 247 mm length is structurally justified under a maximum expected pressure of 1 MPa. The design meets the required safety factor of 1.5 and is well within the yield and burst limits of the material. The structure is deemed fit for static testing.

Prepared by:
Wamburu Ndirangu
Solid Propulsion Team