Analysis of Air Spring

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Constraining the linear motor assembly during a worst case scenario involving power failure during the exhaust stroke has been a serious consideration. In such an event, the motor assembly would be traveling at up to $5\frac{m}{s}$. Assuming a mass of 10kg, we obtain:

$$\begin{aligned} \text{Kinetic Energy} &= \frac{1}{2}mv^2 \\ &= 125J \end{aligned}$$

To absorb this energy we are considering a vented air spring. This spring would start to act 5mm before the piston contacted the head, and bring the piston to a stop .1mm from the end of the spring to allow for modeling errors. We assume atmospheric pressure at 5mm. The air spring has a length L and a projected area of A.

$$\begin{aligned} P * V &= 505 * A \\ P &= \frac{505 * A}{A * L} \\ P &= \frac{505}{L} \end{aligned}$$

Solving the energy equation for A:

$$\begin{aligned} \text{Force} &= (P - P_0) * A \\ \text{Energy} &= \int_{.0001}^{.005} (P - P_0) * A \text{ dL} \\ A &= .0795 \text{ m} \end{aligned}$$

This would require a 16cm radius air spring, which is not feasible with our space constraint.