31.28 An air compressor with a pressure ratio of 8 has air entering at $68°F$ and leaving at $750°F$. What is the isentropic efficinecy?

A. 57%

B. 63%

C. 69%

D. 75%

Temporarily ignore the leaving temperature given and calculate the *ideal* leaving air temperature as though the compression was a Constant Entropy Process. Use the formula below, assuming ideal air with $k = 1.4$ and making sure to use absolute temperature i.e. degrees Rankine.

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$T_{2,ideal} = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = (528°R)\,(8)^{\frac{1.4-1}{1.4}} = 956.4°R$$

$$T_{2,ideal} = 956.4°R - 460 = 496.4°F$$

The efficiency can be determined by the ratio of ideal heating to actual heating. To help rationalize this, recognize that the compression process necessarily increases temperature; however, the goal is to minimize unwanted heating and to use as much of the available input energy as possible for driving the desired increase in pressure.

$$\eta = \frac{\dot{Q}_{ideal}}{\dot{Q}_{actual}} = \frac{\dot{m}c_p\Delta T_{ideal}}{\dot{m}c_p\Delta T_{actual}} = \frac{T_{2,ideal} - T_1}{T_{2,actual} - T_1} = \frac{496.4°F - 68°F}{750°F - 68°F} = 0.628$$

Answer B