31.24 An air compressor has a compression ratio of 10. Air enters at $70°F$ and exits at $250°F$. What is the polytropic exponent for this process?

A. 1.1

B. 1.4

C. 1.9

D. 2.2

For Constant Entropy Processes, the relationship between temperature and pressure ratios is given by the equation shown which depends on the ratio of specific heats, k.

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

For a *polytropic* process, the ratio of specific heats gets replaced with the polytropic exponent, n. Although this is not explicitly stated in the Reference Handbook, it's a well-established concept. Substitute n for k, and use the given pressure ratio, and the known temperatures to solve. Make sure to use absolute temperatures i.e. Rankine.

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

$$\frac{(250+460)}{(70+460)} = (10)^{\frac{n-1}{n}}$$

To simplify the algebra, let $x = \frac{n-1}{n}$. Use logarithms with base 10 to solve for x, then solve for n.

$$1.3396 = 10^x$$

$$x = log_{10}1.3396 = 0.127$$

$$x = \frac{n-1}{n} = 1 - \frac{1}{n} = 0.127$$

$$\frac{1}{n} = 0.873$$

$$n = 1.1$$

Answer A