TOOL: For n independent samples, X_i, from a normal (or gaussian) distribution with mean μ and variance σ^2, the probability density function of the normalized sample variance,

$$\chi^2 = \frac{(n-1)S^2}{\sigma^2} = \nu \frac{S^2}{\sigma^2}$$

(where $\nu = n - 1$, $S^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2$, and $\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$)

has a chi-squared distribution with ν degrees of freedom:

$$\chi^2 \sim \chi^2_\nu$$

or

$$f_{\chi^2}(x) = \begin{cases} \dfrac{1}{2^{\nu/2}\Gamma(\nu/2)} x^{(\nu/2)-1} e^{-x/2} & x > 0 \\ 0 & x \le 0 \end{cases}$$

PROOF: See derivation of χ^2 distribution | (pdf).

REF: Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying Ye, *Probability and Statistics for Engineers and Scientists,* 8th Ed., Upper Saddle River, NJ: Prentice Hall, 2007.