NIST is developing a primary pressure standard based on measuring the temperature and the dielectric permittivity, $\varepsilon$, of helium gas in the pressure range $0.5\ MPa < p < 7\ MPa$. The standard will rely on ab initio calculations of the molar polarizability, the density virial coefficients, and the dielectric virial coefficients of helium. We measured $[\varepsilon(p,T) - 1]$ of helium near 0 °C and 7 MPa using an ellipsoidal microwave cavity resonator. The shape of the cavity completely lifted the triple degeneracy of a few microwave modes, allowing the corresponding resonance frequencies to be measured with part-per billion precision. The walls of the cavity were copper-plated, maraging steel. Near 7 MPa, the relative uncertainty of the measured value of $[\varepsilon(p,T) - 1]$ was $12\times10^{-6}$; this uncertainty was dominated by the uncertain compressibility of the maraging steel, which we determined using resonant ultrasonic spectroscopy.