Anomalous Behavior of Teflon®-based Helium Permeation Flow Standards

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Abstract

Helium leak testing is a vital step in assuring product reliability for anything that must be packaged in a sealed container. Examples abound from blister packaging for pharmaceuticals to aluminum wheel rims for automobiles. In order to quantify detected leaks, mass spectrometer based helium leak detectors must be calibrated with helium flow transfer standards. Best results are obtained when the leak detector is calibrated with a stable transfer standard having a quantified uncertainty. Ideally, the order of magnitude of the helium flow from the transfer standard should be the same as the largest permissible leak rate. Helium permeation leak artifacts are the most popular transfer standards used for this purpose. Though permeation elements are most often made of glass, various fluoropolymers including Teflon® are sometimes used for the leak element in applications where mechanical shock may damage a glass element. Teflon®-based helium leak artifacts are sold by several different manufacturers. The National Institute of Standards and Technology (NIST) calibrates helium permeation leak artifacts as a function of temperature, and has found some anomalous behavior coming from Teflon®-based artifacts in comparison with glass-based artifacts. These anomalies include hysteretic effects which are much larger than the uncertainty of the measured leak rate, and sudden jumps (up or down) in the measured leak rate as a function of temperature. This behavior has been attributed to the well documented phase transitions that occur in copolymers of Teflon near room temperature (19 oC and 30 oC). Many commercial laboratories perform calibrations on permeation leak artifacts at only one temperature, and assume the temperature dependence from an empirical model. This type of calibration would miss the cited anomalies and grossly underestimate the uncertainty of the measured leak rate. Data on commercially available Teflon®-based leak artifacts as well as some made in-house at NIST will be presented. This information may be helpful in deciding which type of permeation transfer standard to use to calibrate a helium leak detector for a given leak testing application.