A Breakthrough in Shelf-Life Evaluation and Quality Assurance

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More than 150 years ago, French physician Jean Louis Marie Poiseuille developed a formula for calculating the flow of blood in different parts of the body. At about the same time, German physicist Gotthilf Heinrich Ludwig Hagen independently arrived at that same formula while measuring the flow of water through a tube. What does blood or water flow have to do with 21 st century packaging? Plenty!

Poiseuille's Law (also known as the Hagen-Poiseuille Law) was the key MOCON researchers used to unlock a revolutionary new means to quickly, accurately, and cost-effectively evaluate the shelf life of flexible and semi-rigid packaging.

Oxygen — the thief of shelf life

Multilayer flexible polymers and semi-rigid plastics offer significant life-cycle cost savings over heavier materials such as glass, steel, and aluminum in many retail packaging applications. Polymers and semi-rigid plastics, however, are more prone than denser materials to oxygen (O 2) ingress from both permeation and leakage due to pin holes and improperly sealed seams.

Minimizing O 2 in a sealed package is essential if anticipated shelf life is to be reached. Packaging engineers do so by specifying optimum barrier properties in a multilayer polymer or semi-rigid plastic to decrease the rate of permeation. They also use a modified atmosphere strategy to reduce O 2 to single digits as a percentage of total volume of gas in the package.

During development of a new package, engineers conduct individual tests to measure permeation, O 2 content in a sealed package, the void volume, and O 2 ingress from imperfections in the material or seams. For packages in production, quality assurance personnel measure O 2 content, void-volume, and material or process imperfections leading to package leaks.

Leak detection

One way to determine whether there is a leak in a flexible or semi-rigid package is the pressure method. In this test, a probe is inserted into the sealed package, air is pumped in, and test equipment measures any differential loss over time. The pressure method of leak testing cannot precisely measure hole size. Additional accuracy problems with the pressure approach stems from package burst, seam creep, and the complex interaction of gasses. Pressure regulators and flow sensors increase the cost of test equipment.

Using a vacuum is another method of leak detection. Removing the atmosphere in a package – creating a vacuum – is a more accurate leak measurement because there are no burst or creep issues. Test instruments are able to detect the presence of a leak but the determination of the actual size of the leak isn't precise. Vacuum control technology increases the cost of the equipment.

Leak detection and Poiseuille's Law

Poiseuille's Law states that given pressure, flow, and hole length (whether material thickness in the case of a pin hole leak, or seam length in the case of a channel leak) absolute aggregate hole size can be determined. Using Poiseuille's law for testing leakage offers a number of advantages over volume or vacuum measurements:

- Measures absolute leak size directly
- More repeatable and accurate
- Valid for most package leak sizes
- Comparison type calibrations not required
- Leak size will be measured correctly at any simultaneous pressure/flow measurement
- Costly pressure/vacuum control is not required

In the application of Poiseuille's Law for leak measurement, a probe is inserted into a package and the atmosphere inside is drawn out. The equipment measures pressure and flow and calculates total aggregate hole size. MOCON researchers realized that as the gasses are removed from the package, two additional measurements could be completed at the same time — O_2 content and void volume. MOCON personnel saw the opportunity of creating a first-of-its-kind three-in-one tester that would perform O_2 shelf-life evaluation faster, more accurately, and at less cost than ever before.

The company allocated the research and development funds to commercialize a three-in-one analyser. During this process, MOCON was awarded two patents and has a number of patents pending. In 2006, MOCON introduced the PAC CHECK ® package integrity analyser — a bench top unit, model 840, and a hand-held portable unit, model 820. Now rather than purchasing three stand-alone testers for shelf-life evaluation, packaged goods companies can buy one bench top or portable unit at a significant savings. One test rather than three is quicker, and there will be less scrap because fewer packages will be required for evaluation.

Furthermore and most importantly, with these three key parameters used in combination with oxygen transmission rate information for a packaging material, it is now possible for the first time to determine actual shelf-life for oxygen sensitive products at time of production.

The integrity analyser incorporates a number of innovative features beyond calculating the real and absolute leak size, O_2 content, and void volume, including:

- National Institute of Standards and Technology traceable leaks for instrument validation
- High-speed pump on the bench top model for fast analysis of large packages
- Detects any blockage of sample flow into the instrument
- Safety probe pierces package, not skin
- Low and high alarm settings
- Stores up to 240 individual product test methods
- Stores up to 240 test results that can be sorted by multiple criteria
- Optional PC-based analysis software available

Innovative thinking, like applying a 150 year old formula to solve a 21^{st} century problem, can only take a development part way to fruition. Making innovation come to life for customers, such as the three-in-one analyser, requires an organization to invest in the best talent, commit significant resources, and have the determination to stretch the boundaries of what others consider possible.