WHITE PAPER

CO_2 TRANSMISSION RATE TEST METHOD BENEFITS FOR YOUR APPLICATION

AMETEK MOCON

March 2026

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WHY CO_2TR TESTING IS IMPORTANT

Abstract

Measuring Carbon Dioxide Transmission Rate (CO_2TR) is essential in several industries where CO_2 either protects product quality or where CO_2 ingress can degrade product stability. Because CO_2 behaves differently from oxygen and water vapor—being more soluble and diffusive in many polymers—specialized CO_2TR analysis is necessary to ensure safety, quality and shelf life.

Introduction: Key Industry Considerations for CO_2 Transmission Rate Testing

Understanding CO_2TR is essential across beverage, food, medical and pharmaceutical packaging because it directly influences product quality, stability and shelf-life performance.

Beverage factory

Beverage Industry (Carbonated Soft Drinks & Sparkling Beverages)

Manufacturers optimize bottle design, closure torque, and resin selection to maintain carbonation throughout distribution and storage. Applications include PET bottles with coatings and multilayers, closure liner evaluations, shelf-life modeling for carbonation retention and quality control for bottle closure systems.

- Carbonation defines taste, mouthfeel, and product identity.
- CO_2 loss directly reduces perceived quality and shelf life.
- Closures, bottle finishes and thin-wall PET containers can be dominant leakage pathways.

Packaged shrimp

Food Industry (Modified Atmosphere Packaging / MAP)

Many foods are packaged with CO_2-rich atmospheres to suppress microbial growth and extend shelf life. CO_2TR helps manufacturers select films that maintain the correct internal atmosphere to ensure safety and freshness. Foods commonly packaged with CO_2 include shredded and sliced cheese, fresh-cut produce, meat and poultry.

- CO_2 helps inhibit spoilage organisms.
- High CO_2 concentrations can collapse packaging if films have poor gas barrier balance.
- CO_2 exchange alters the headspace mix, impacting freshness.

All-purpose catheters

Medical Device Packaging

CO_2TR ensures packaging maintains the correct chemical environment to preserve drug potency and safety. Packaging types that benefit from this include IV bags (EVA, PP, multilayer films), biologic drug pouches, serum and buffer containers and clinical solution bags.

- CO_2 dissolves into aqueous solutions, forming carbonic acid, which can shift pH and destabilize proteins or biologic therapeutics.
- Fitments, ports, and welded seams can contribute to unwanted CO_2 ingress.

Vacutainers

Pharmaceutical & Diagnostic Products

Manufacturers use CO_2TR to validate packaging systems and ensure regulatory compliance for stability until expiration. Examples include medicine vials, diagnostic reagent bottles and dry powder or lyophilized drug containers.

- CO_2 may alter reactive compounds or buffering systems.
- Sensitive powders can absorb CO_2 and degrade.
- Headspace stability is essential for accurate diagnostic performance.

CO_2TR FLAT FILM TESTING METHOD

Carbon Dioxide Transmission Rate Test Methodology

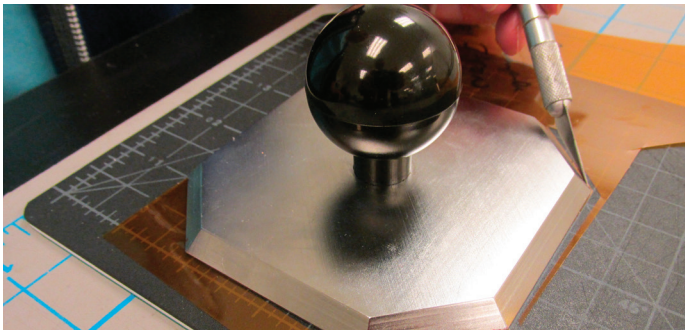
CO_2TR testing follows ASTM F2476 and is analogous to oxygen transmission rate (OTR, ASTM D3985) and water vapor transmission rate (WVTR, ASTM F1249) methods. These tests quantify gas permeation through packaging materials under controlled conditions.

How CO_2 Film Testing Is Conducted (ASTM F2476)

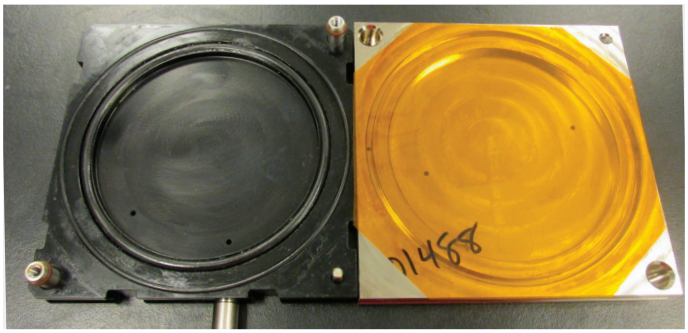
A representative film sample (e.g., pouch sidewall) is sectioned from a larger piece (Fig. 1) and mounted in a diffusion cell (Fig. 2). The mounted sample is placed in a PERMATRAN-C® 4/30 instrument, where temperature and test conditions are precisely controlled (Fig. 3).

- One side of the sample is exposed to CO_2 test gas
- The opposite side is swept with dry nitrogen (N_2) carrier gas
- Any CO_2 permeating through the sample is transported by N_2 to a pressure-modulated infrared detector
- The detector quantifies CO_2 concentration, reported as cc/(m^2 • day)

AMETEK MOCON pioneered CO_2TR testing over 25 years ago. With precise temperature control, gas flow regulation, and calibrated reference films, these instruments have become the global standard for CO_2 permeability measurement.

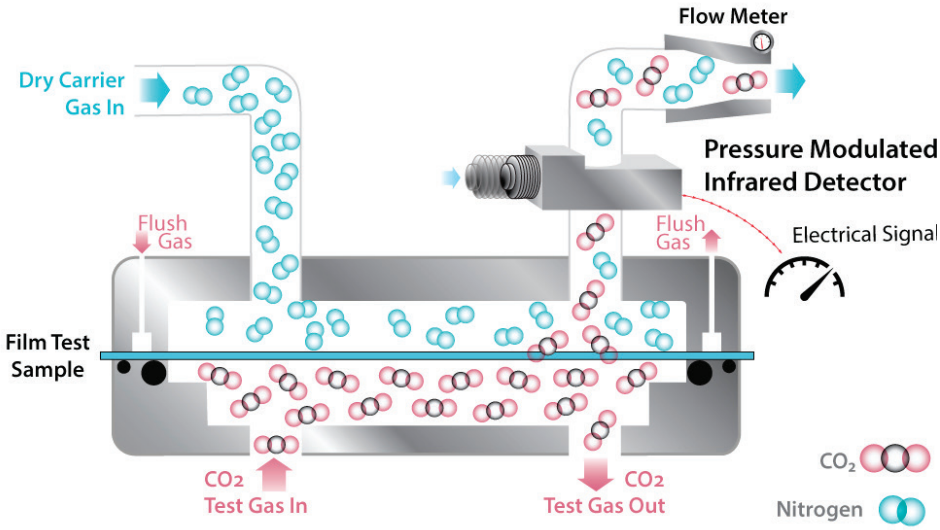


(Fig. 1) Cutting a sample



(Fig. 2) Placing the sample onto a diffusion cell

PERMATRAN-C® 4/30



(Fig. 3) Method schematic

BARRIER SYSTEM EVALUATION

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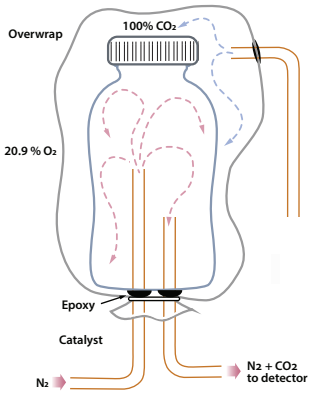
Whole-Package CO_2 Testing

Many applications require characterization of the entire package, including seals, closures and fitments (e.g., pouches, bottles, IV bags, tubing and blister packaging). Whole-package testing (Fig. 4) follows the same preparation principles as an OTR package test (ASTM F1307), with the following distinction:

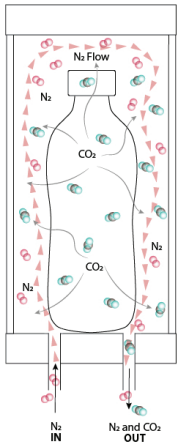
- The package exterior is challenged with CO_2 test gas
- Dry N_2 sweeps the interior of the package
- Transmitted CO_2 is measured using the PERMATRAN-C® 4/30 infrared detector (the same detection system used for film testing)

CO_2 Loss ("Outgassing") Testing

For applications such as carbonated beverages, the goal is to measure CO_2 loss from inside the package. A carbonated solution is sealed in the sample and placed in a capture vessel (Fig. 5). Dry N_2 sweeps around the package, carrying any permeated CO_2 to the infrared detector for quantification. Testing in this manner is much faster than the Zahm-Nagle (ASTM F1115) method for CO_2 barrier comparisons.



(Fig. 4) Testing the bottle for ingress



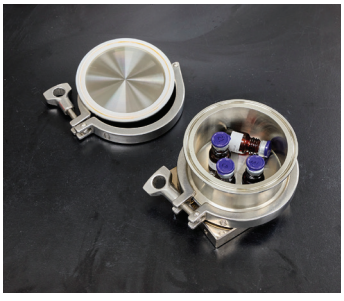
(Fig. 5) Testing the bottle for CO_2 loss

Results are reported as cc/(package • day), reflecting total CO_2 loss from the complete package system, including seals and closures.

EXPERTISE & SUPPORT

We go beyond industry-leading instruments and accessories

Since 1966, we have set the industry standard in precision gas permeation testing and package testing instrumentation. Our dedicated team and innovative products offer the best value with an extensive range of solutions. Trusted by companies worldwide, we deliver the most accurate and repeatable results to ensure and enhance the quality and integrity of product packaging.



Custom application development and lab testing services for industries like health care, packaging and food & beverage

Since 1966, over 70 patents have been awarded for instruments developed by AMETEK MOCON

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WP-PPS-3012-CO2TR Test Method Benefits-0326-1.0

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