



PERMEATION RESISTANCE OF BARRIER MATERIALS TO HAZARDOUS LIQUIDS, VAPORS, AND GASES

SUMMARY

The White Sands Test Facility (WSTF) has extensive experience determining the permeation resistance of materials used in totally encapsulating chemical-protective suits, laboratory personal protective equipment (PPE), and space suits. Sheetting, film, and seals used in miscellaneous barrier applications can also be tested. WSTF develops and applies state-of-the-art analytical techniques for determining levels of hazardous chemicals below currently mandated exposure limits. Some of the chemicals routinely determined include hydrazines, dinitrogen tetroxide, cleaning solvents, and breathing gases. Permeation testing is generally conducted in accordance with ASTM F-739 by measuring the breakthrough time and subsequent transmission rate of the chemical through the barrier material. Changes accompanying permeation such as swelling, chemical modification, and degradation can be determined. Both discrete and continuous sampling is available. Tests may be conducted at ambient or differential pressure. Any conceivable exposure scenario can be simulated, including vapor exposure, at variable concentration or relative percent humidity, liquid exposure, and sequential exposure/re-exposure scenarios.

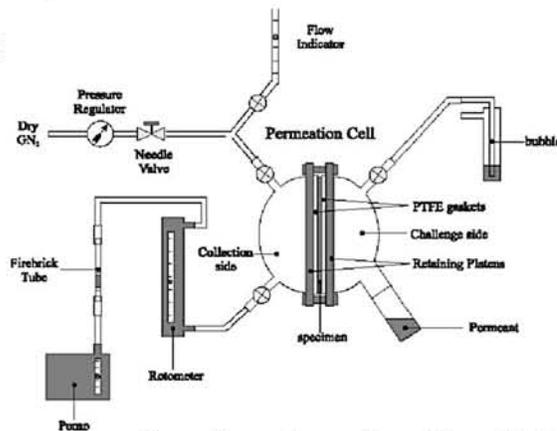
APPARATUS AND BASIS OF TECHNIQUE

The test specimen is mounted inside a permeation cell, dividing the cell into two chambers. The challenge chemical is introduced into one chamber, while an inert gas or liquid flowing through the other chamber is sampled for the presence of permeant. A diagram of the WSTF permeation system configured for ambient pressure permeation of liquid propellant fuel is shown to the right. As permeant migrates through the specimen, detectable levels are reached on the collection side of the cell at the breakthrough time. The collecting medium can be continuously or discretely sampled, and a corresponding instantaneous or time-averaged permeant concentration determined as a function of time.

The permeant concentration after breakthrough is readily converted to a permeation rate, P (dimensions: $mass\ area^{-1}time^{-1}$), as follows:

$$P = C \frac{F}{A},$$

where C is the analytically determined permeant concentration, F is the flow rate of the collecting medium through the cell, and A is the specimen area.



Permeation system configured for ambient pressure permeation of liquid propellant



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Breakthrough time and permeation rate data can be used to evaluate the permeation resistance of materials for screening or qualification purposes. Permeation rate data can also be used to calculate accurate ppm- and ppb-level permeant concentrations inside totally encapsulating chemical-protective suits or space suits under well-defined operational conditions. Permeation rate data can yield information about possible inertness, swelling, or degradation of test materials.

TEST SAMPLES AND CHEMICALS

Permeation resistance testing is generally used to evaluate swatches of material taken from protective garments such as gloves, face shields, boots, aprons, respirators, hats or encapsulating suits. However, any barrier material suspected of permeation can be tested. Discontinuous areas such as seams can be tested in addition to continuous regions. Although disk-shaped specimens with diameters of approximately 6 cm (2.5 in.) are usually tested, fixtures can be used to accommodate specimens of virtually any geometry. Test chemicals may consist of virtually any hazardous liquid or gas posing a potential threat to personnel or operational safety. Of special interest to NASA are hypergolic aerospace propellants.

APPLICATIONS

WSTF is poised to determine the permeation resistance of barrier materials against hazardous aerospace liquids or gases. Corresponding applications include:

- Chemical-protective suits
- Space suits
- Laboratory PPE
- Sheeting, films, and seals used in miscellaneous barrier applications

CONTACT

Mark B. McClure, NASA White Sands Test Facility, Project Manager
mark.b.mcclure@nasa.gov, 575.524.5488

