INTERNATIONAL PERMEATION MEASUREMENT STANDARDS

Christoph Zerwas
Area Sales Manager - Europe
Permeation Testing Systems
MOCON GmbH

Standardisation organisations

- **ASTM:** ASTM International, formerly known as American Society for Testing and Materials
- **ISO:** International Organization for Standardization
- **DIN:** Deutsches Institut für Normung e. V.
- **TAPPI:** Technological Association of the Pulp and Paper Industry

Standards for permeation measurement

ASTM D 1434	ASTM F 2476	JIS K-7126
ASTM D 1653	ASTM F 2622	JIS K-7129
ASTM D 2684	DIN EN ISO 12572	JIS Z-0208
ASTM D 3079	DIN EN 13726-2	JIS Z-0222
ASTM D 3833/M	DIN 16995	TAPPI T 448
ASTM D 3985	DIN 53122	TAPPI/ANSI T 464
ASTM D 4279	DIN 53380	TAPPI T 557
ASTM D 4491	ISO 1663	WSP 70.4
ASTM E 96/E 96M	ISO 2528	WSP 70.5
ASTM E 398	ISO 2556	WSP 70.6
ASTM F 1115	ISO 7229	…
ASTM F 1249	ISO 9932	
ASTM F 1306	ISO 15105	
ASTM F 1307	ISO 15106	
ASTM F 1927	ISO 18369	

Differences between standards

- Test gas
- Type of samples
- Method and type of sensor
- Measurement conditions

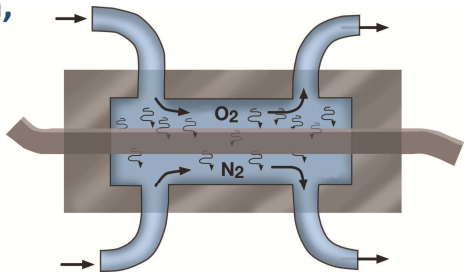
Most important international standards

OTR:	WVTR:	CO_2TR:
ASTM D 3985	ASTM F 1249	ASTM F 2476
ASTM F 1307	ASTM E 398	DIN 53380-4
ASTM F 1927	ASTM E 96	
ASTM F 2622	ISO 15106	
ISO 15105	WSP 070.4.R3	
DIN 53380-3	DIN 53122	

Oxygen Transmission Rate (OTR)

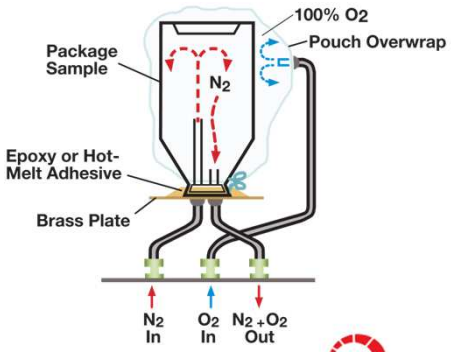
ASTM D 3985

- OTR measurement through plastic film and sheeting including laminates, coextrusions, plastic-coated paper or fabrics
- using a coulometric sensor
- carrier gas method
  (nitrogen + 0,5 to 3 % hydrogen, e.g. forming gas)
- dry gas only
- controlled temperature
- most important OTR standard



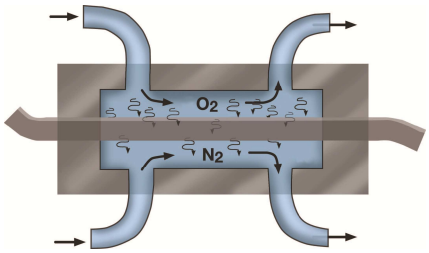
ASTM F 1307

- OTR measurement through dry packages
- using a coulometric sensor
- carrier gas method
  (transmission from outside into the package)
- either 100 % O_2 or
  ambient room air (20,8 % O_2)
- controlled temperature



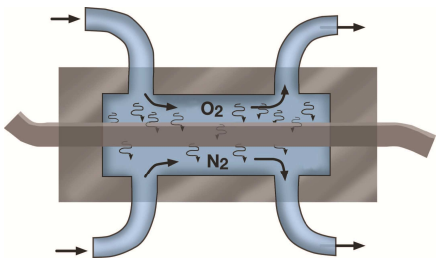
ASTM F 1927

- OTR measurement through barrier materials at controlled relative humidity
- coulometric sensor
- carrier gas method
- controlled temperature and relative humidity



ASTM F 2622

- OTR measurement through plastic film and sheeting including laminates, coextrusions, plastic-coated paper or fabrics
- using various sensors including coulometric, electrochemical and zirconium oxide
- carrier gas method (nitrogen)
- controlled temperature and relative humidity



ISO 15105

- transmission rate testing of various gases
- for plastic film, sheeting, laminates, co-extruded materials or flexible plastic-coated material
- carrier gas method
- controlled temperature and relative humidity
- part 1: differential pressure method
  2: equal pressure method
- various sensors, depending on type of test gas
  - Annex A: coulometric sensor for OTR
  - Annex B: chromatographic sensor for various gases

DIN 53380

- Determining gas transmission rate through plastic films, sheeting and mouldings such as packaging containers and tubes
- transmission rates ranging
  - 0,05 to 1.000 $cm^3/(m^2 * d)$ for films
  - 0,0005 to 10 cm^3/d for hollow bodies
- various sensors
- controlled temperature and relative humidity
- part 1: volumetric testing of plastic films
  2: manometric testing of plastic films
  3: oxygen specific carrier gas method for films
  4: CO_2TR testing by infrared absorption method

MOCON instruments for OTR measurement

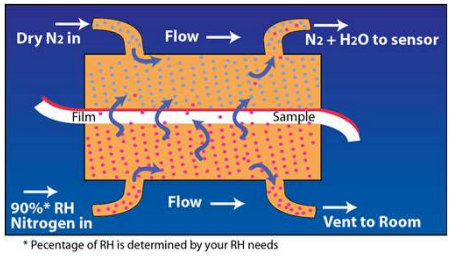
Standard	MOCON instrument
ASTM D 3985	OX-TRAN 2/22, 2/21, 2/61, 702, 1/50
ASTM F 1307	OX-TRAN 2/22, 2/21, 2/61, 702
ASTM F 1927	OX-TRAN 2/22, 2/21, 2/61, 702 (dry), 1/50 (films)
ASTM F 2622	OX-TRAN 2/10
ISO 15105-2	OX-TRAN 2/22, 2/21, 2/61, 702 (dry), 2/10, 1/50
DIN 53380-3	OX-TRAN 2/22, 2/21, 2/61, 702 (dry), 2/10

Water Vapour Transmission Rate (WVTR)

www.mocon.eu Christoph Zerwas

ASTM F 1249

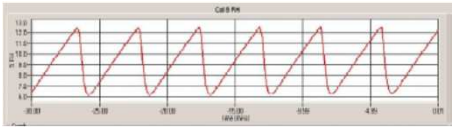
- WVTR measurement through flexible barrier materials, sheets and films up to 3 mm in thickness
- using a pressure-modulated infrared sensor
- carrier gas method
- controlled temperature and relative humidity
- most important WVTR standard

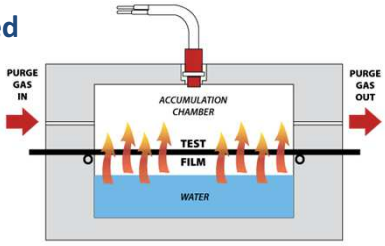


* Pecentage of RH is determined by your RH needs

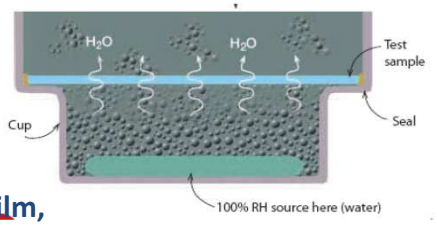
ASTM E 398

- WVTR measurement through flexible barrier sheet materials
- using dynamic relative humidity measurement by means of any kind of sensor capable of detecting changes of 0,05 % RH
- accumulation method
- minimum test value approximately 0,01 g/(m² * d)
- controlled temperature and relative humidity
- commonly used conditions: 37,8 °C and 90 or 100 % RH diff. other conditions are possible and allowed
- similar standard ISO 15106-1





ASTM E 96



- WVT measurement
- for various materials like paper, plastic film, sheeting, fiberboards, gypsum and wood products up to 32 mm
- open dish (cup) sealed by the sample and placed in a controlled atmosphere => cup test
- gravimetric measurement
- 2 methods:
  - desiccant method: desiccant in the dish
    water moving through the sample into the desiccant
  - water method: distilled water in the dish
    water leaving the dish through the sample
- suggestion of 23/32,2/37,8 °C with 50/90 % RH

ISO 15106

- WVTR measurement through plastic film, sheeting and multilayer structures including plastics
- 7 parts:
  - 1 (2003): humidity sensor method, similar to ASTM E 398
  - 2 (2003): infrared sensor method, similar to ASTM F 1249
  - 3 (2003): electrolytic sensor method, replaced DIN 53122-2
  - 4 (2008): gas-chromatographic sensor method
  - 5 (2015): pressure sensor method
  - 6 (2015): atmospheric pressure ionization mass spectrometer method
  - 7 (2015): calcium corrosion method

ISO 15106

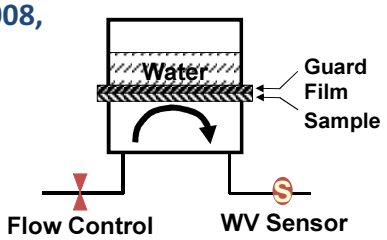
5 different conditions are described but not mandatory:

Set of conditions	Temperature °C	Desired RH differential	RH of upper chamber *	RH of lower chamber *
1	25 ± 0,5	90	10	100
2	38 ± 0,5	90	10	100
3	40 ± 0,5	90	10	100
4	23 ± 0,5	85	15	100
5	25 ± 0,5	75	25	100

* only part 1

WSP 070.4.R3

- WVTR measurement through high transmitting flexible barrier materials in the form of films and sheeting up to 3 mm in thickn.
- using a water vapour detector capable of measuring 500 to 100.000 g/(m² * d)
- using a guard film
- instrument with 6 test cells
- controlled temperature in a range of 20 to 50 °C
- similar to ASTM D 6701, withdrawn 2008, reinstated 2015



DIN 53122

Part 1:

- **WVTR measurement through plastics and elastomer films, paper, board and other sheet materials**
- **using gravimetric method**
- **similar to ASTM E 96**

Part 2: withdrawn and replaced by ISO 15106-3

MOCON instruments for WVTR measurem.

Standard	MOCON instrument
ASTM F 1249	PERMATRAN-W 3/34, 3/33, 3/61, 700
ASTM E 398	PERMATRAN-W 1/50, 398
ISO 15106-1	PERMATRAN-W 1/50, 398
ISO 15106-2	PERMATRAN-W 3/34, 3/33, 3/61, 700
ISO 15106-3	AQUATRAN
WSP 070.4.R3	PERMATRAN-W 101K

Carbon Dioxide Transmission Rate (CO_2TR)

ASTM F 2476

- CO_2TR measurement through plastic film and sheeting including laminates, coextrusions and plastic-coated papers or fabrics
- using an infrared sensor
- carrier gas method (nitrogen)
- dry test conditions
- controlled temperature

MOCON instruments for CO_2TR measurement

Standard	MOCON instrument
ASTM F 2476	PERMATRAN-C 4/41
DIN 53380-4	PERMATRAN-C 4/41

Special Applications

Standards for special applications

- ASTM D 1653 Standard test method for water vapor transmission of organic coating films
- ASTM D 3833 Standard test method for water vapor transmission of pressure-sensitive tapes
- DIN EN ISO 12572 Determination of water vapour transmission properties of building materials and products
- ISO 18369-4 Physicochemical properties (incl. oxygen permeability) of contact lens materials

Conclusion

To be able to compare transmission rate values, testing should be done according to an established, international standard.

The standard which is most suitable for your application (film or package? dry or humid?...) should be used.

www.mocon.eu

This presentation is not intended to be exhaustive.