Labthink Instruments Co., Ltd.
144 Wuyingshan Road, Jinan, P.R.China
Phone: +86 531 85068566
FAX: +86 531 85812140

Gas Transmission Rate, Permeance and Permeability Coefficient Application Guide

Abstract: the article detailed introduced the definition, application range, and the difference and conversion relationships of 3 permeability parameters (gas transmission rate, permeance and permeability coefficient). Furthermore, it also explained the unclear situations in the international and national standards.
Key Words: permeability, transmission rate, permeance, permeability coefficient

There are some slight differences between national and international definitions of permeability parameters, which causes confusion in parameter concept and application. The situation will not affect the transfer of data but the evaluation to the materials. This article focuses on the analysis of the transmission rate of the permeability parametric gas, the permeance and the definition of gas permeability coefficient. The article also introduced the relationships between them and important issues in application.

Chapter one: the standard definition of gas permeability parameter

Because carrier gas (N_2) reversely transmits in the equal pressure method, the method is essentially different with the manometry method. The difference may affect to methods' application range and parameter definitions (for example, the equal pressure method is mostly applied to oxygen gas test, but the manometry method has barely had any requirements to test gas). As a result, this article introduces the definitions of permeability parameters according to the types of testing methods.

1.1 Manometric method

1.1.1 ASRM D1434-82

In ASRM D1434-82, there are three descriptions of permeability parameters:

1. Gas Transmission Rate (GTR): The quantity of a given gas passing through a unit of the parallel surfaces of a plastic film in unit time under the conditions of test. The SI unit of GTR is 1 mol / (m^2·s).

2. Permeance (P): The ratio of the gas transmission rate to the difference in partial pressure of the gas on the two sides of the film. The SI unit of permeance is 1 mol / (m^2·s·Pa).

3. Permeability (P): The product of the permeance and the thickness of a film. The SI unit of P is 1 mol / (m·s·Pa).

1.1.2 ISO 2556:2001

There is only one description of permeability parameter in ISO 2556:2001:

Gas transmission rate: The volume of gas which, under steady conditions, crosses unit area of the sample in unit time under unit pressure difference and at constant temperature. The rate is usually expressed in cm^3 / m^2·d·atm.

1.1.3 GB/T 1038-2000

There are two descriptions of permeability parameters in GB/T 1038-2000:

1. permeance (Q_g): The volume of gas which, under steady conditions, crosses unit area of the sample in unit time under unit pressure difference and at constant temperature. The rate is usually expressed in **cm^3 / m^2·d·Pa.**

2. Permeability coefficient (p_g): The volume of gas which, under steady conditions, crosses unit area and unit thickness of the sample in unit time under unit pressure difference and at constant temperature. The rate is usually expressed in **cm^3 ·cm/ m^2·s·Pa.**

1.1.4 Conclusion

Through the analysis of the standard definition and result unit, in GB/T 1038-2000、ASTM D1434-82、ISO 2556:2001, the definition of the gas permeability coefficient is the same; the expression of the permeance is different, GB/T 1038-2000 'permeance (Q_g)'= ASTM D1434 'Permeance (P)' = ISO 2556 'Gas transmission rate', the units could all be transformed to cm^3 / m^2·24h·0.1MPa.

1.2 Equal pressure method

1.2.1 ASTM D3985-05

There are three descriptions of permeability parameters:

1. Oxygen Transmission Rate (O_2GTR): The quantity of oxygen gas passing through a unit area of the parallel surfaces of a plastic film per unit time under the conditions of test. The SI unit of transmission rate is the **mol / (m^2·s)**.

2. Oxygen Permeance (PO_2): The ratio of the O_2GTR to the difference between the partial pressure of O_2 on the two sides of the film. The SI unit of permeance is the **mol / (m^2·s·Pa)**.

3. Oxygen Permeability Coefficient (P'O_2): The product of the permeance and the thickness of film. The SI unit of oxygen permeability is the **mol / (m·s·Pa)**.

1.2.2 ISO 15105-2:2003

There are two descriptions of permeability parameters in ISO 15105-2:2003:

1. Gas-transmission rate (GTR): Volume of gas passing through a plastic material, per unit area and unit time, under unit partial-pressure difference between the two sides of the material. O_2GTR is the oxygen-transmission rate, expressed in moles per square metre second pascal [**mol / (m^2·s·Pa)**]. O_2GTR is generally expressed in cubic centimetres per square metre 24h [**cm^3 / (m^2·24h)**].

2. Gas permeability (P): Volume of gas passing through a plastic material of unit thickness, per unit area and unit time, under unit partial-pressure difference between the two sides of the material. P is expressed in mole metres per square metre second pascal [**mol·m / m^2·s·Pa**].

1.2.3 GB/T 19789-2005

There are three descriptions of permeability parameters in GB/T 19789-2005:

1. Oxygen transmission rate (O_2GTR): Volume of oxygen passing through a specimen material, per unit area and unit time, under test conditions. O_2GTR is generally expressed in **cm^3 / (m^2·24h)**.

2. oxygen permeance (PO_2): The ratio of the O_2GTR to the difference between the partial pressure of O_2 on the two sides of the film. The unit of permeance is the **cm^3 / (m^2·24h·0.1MPa).**

3. Oxygen Permeability Coefficient ($\overline{PO}_2$): The product of the permeance and the thickness of film. The unit of oxygen permeability is the **cm^3 / (m·24h·0.1MPa)**.

1.2.4 conclusion

By the analysis to the standard definitions and the result units, to the equal pressure method, the definitions and units of oxygen permeability coefficient is the same in GB/T 19789-2005、ASTM D3985-05、ISO 15105-2:2003, the only difference is that the GB/T 19789-2005 translated it to oxygen permeability coefficient; the expressions of the gas permeance are different, GB/T 19789-2005 'oxygen permeance (PO_2)'= ASTM D3985-05 'Oxygen Permeance (PO_2)'= 15105-2:2003 'Gas-transmission rate (GTR)'. It is noticeable that ISO 15105-2:2003 could not only be applied to oxygen permeability test, thus it did not restrain the concept of permeability parameter in the limit of oxygen test.

Chapter two: the application of permeability parameters

The gas permeability rate means the volume of the gas, which passes through unit area of specimen in a unit time, it is determined by the barrier property of the material and the partial pressure difference between two sides of the specimen. The gas permeability rate is determined by the test conditions and the specimen itself. The permeance is only determined by the specimen itself. As to the gas permeability coefficient, it is determined by the properties of the specimen material.

Usually, the permeance (cm^3 / m^2·24h·0.1MPa) and the gas transmission rate are the only things being concerned. Besides the influence of the standard definition difference, technically speaking, the gas transmission rate has been barely applied. That is because the rate is usually influenced by the gas partial pressure difference and thus unfavorable to data comparison. Moreover, some misunderstanding to the application of gas transmission rate does exist. The rate could not be applied to every material but to the even single layer material. Before the application, tests to many other material thickness should be passed and proved to be consistent. To multi-layer materials the test of gas transmission rate is meaningless. The rate serves to design multi-layer material structures.

Chapter three: conclusion

Attention should be drawn to the differences in the definitions and units of permeability parameters. As to the users, the meanings of parameters from different standards shall be confirmed by comparing the result units; the parameters' tag should not be the only thing being concerned in order to avoid confusion in data comparison and communication.