

Gas Permeability Testing and Air Permeability Testing of Materials

Abstract: Based on the requirements of material gas permeability testing, this article introduces testing methods of gas permeability testing and air permeability testing.

Keywords: permeability , gas permeability , air permeability , film , nonmetal

Gas permeability testing of materials is one of the important indexes in its physical property testing. Low permeability material is known as possessing certain barrier property to gases. Among them, materials with extremely low auto gas permeability are called barrier materials and are massively used as functional materials (such as commodity package). High permeability materials are said in relation to materials with certain barrier property. Being versatile materials, they possess great gas permeability and plenty of varieties.

1. Gas Permeability Testing

Gas permeability testing is to carry out permeability testing of specific gases to materials with certain gas barrier property. Most of these materials are macromolecule polymer or multi-layer complex materials made of high polymer and are widely used in the field of product packaging such as food, pharmaceutical, chemical, electronics and military, etc. Among them, materials with very good barrier property (low auto gas permeability) can be used in package of commodities that are sensitive to oxygen and water vapors. This kind of materials is the focus of the development of plastic package industry in recent years and is also the developing base for new types of package such as gas packing, vacuum packing and sterile packing.

Gas permeability testing of materials is mainly carried out with differential pressure method and equal pressure method, and the former is the most widely used one(detailed information can refer to the article named Gas Permeability Testing and Its Testing Instruments updated on October 10 to 17, 2005 in Labthink Lab Forum). As a complete physical testing method and fundamental testing method in gas permeability testing, testing principle of differential method is clear and intelligible and is similar to that of air permeability testing instruments. Differential pressure method can be further divided into vacuum method and positive method. According to the requirements of testing standards, vacuum gauge or gauge pressure sensor with extremely high resolution should be adopted. Minute changes of pressure in testing process must be precisely recorded.

Gas permeability testing has the following characteristics:

Firstly, to gas permeability testing instruments of vacuum differential pressure method, vacuum degree of testing chambers is one of the most important indexes. As stated in standard ASTM D 1434-82(2003), low pressure side is required to be less than 26Pa, while in standards ISO 2556:2001and GB/T 1038-2000, that should not exceed 27Pa. Gas permeability instrument should be equipped with vacuum pump of very high vacuum pumping ability. Since vacuum degree have direct link with status of the specimens, whether the required vacuum degree can be satisfied will exert certain influences on testing data.

Secondly, precision of vacuum gauge can directly influence precision of testing results. Moreover, precision

selection will impose certain limitation on measuring range of vacuum gauge. Since this kind of materials is low in gas permeability, and pressure variation ratio of lower testing chamber during testing process is also very small, large measuring range is not necessary for vacuum gauge. Oxygen permeability testing data of five high permeability materials are listed in table 1. In this group of testing, maximum pressure variation was not larger than 20Pa until the end of testing.

Table 1. Data List of Oxygen Permeability Testing

Material	Temperature ℃	Humidity %RH	Thickness μm	Testing Duration h	Pressure at the End of Test Pa	Gas Permeability Quantity ml/m ² ·24h·0.1MPa
A	24.2	63.8	90	22.0	2.47	0.05
B	24.3	53.6	100	7.5	8.22	1.04
C	24.1	58.6	100	6.4	15.07	2.01
D	21.4	42.3	250	2.1	9.32	3.467
E	23.1	27.1	60	2.7	12.60	5.44

Thirdly, temperature fluctuation can directly influence barrier property of specimens. Its influences on permeability coefficient, solubility coefficient and diffusion coefficient follow Arrhenius equation.

At present, professional gas permeability instruments used for material of low gas permeability develop rather rapidly. Labthink VAC-V1 Gas Permeability Tester can completely satisfy domestic and ISO standards with powerful functions.

2. Air Permeability Testing

When high gas permeability materials such as plastic foam, leather, textile, cardboard, paper, porous ceramics and so on are used in some specific fields, gas permeability of these materials should be quantified. For example, gas permeability of cigarette paper can impose direct influences on the appearance, smell and content of fume of cigarette, while gas permeability controlling of textile is a key factor for wearing amenity of clothes. Gas permeability testing for this kind of material is called air permeability testing; in which professional air permeability testers should be adopted.

Testing methods for the above mentioned materials can be divided into two kinds: testing differential pressure by fixed flux and testing flux by fixed differential pressure (for detailed information please refer to Automobile Technology in September, 2005 and Material and Air Permeability Testing for Automobile nonmetal in October, 2005). The former one is mainly used in the testing of polyurethane foam plastics as well as flexible or semi-rigid multi hole elastic materials. While the latter one is mainly used for the testing of textile, non-woven fabrics, leather and so on. In air permeability testing of paper and leather, the time needed by certain volume of air transmitting through specimens under specified differential pressure should be tested, which may be classified as test mode of testing flux by fixed differential pressure, and then, the tested flux are used for further calculation.

Comparing with the above introduced gas permeability testing, air permeability testing possess the following characteristics:

First, test objects are different. Gas permeability testing is mainly used in film testing, while air permeability testing

is mainly used in the testing of multi-hole materials and non-woven fabrics.

Secondly, gas permeability testing can be used for material permeability testing of oxygen, nitrogen gas, carbon dioxide and air, while air permeability testing is mainly used for permeability testing of materials to air.

Thirdly, the lengths of testing time vary a lot. Testing time of air permeability testing is a lot shorter than that of gas permeability testing; the reason for which is that the gas permeability property of the materials being tested by these two methods are greatly different.

Fourth, since air permeability testing is mainly used for material of high gas permeability, the instruments will not need high sensitive vacuum gauge or pressure sensor, and its demand on vacuum pumping ability of vacuum pump is also comparatively low. However, to satisfy testing requirements of different gas transmitting quantity, pressure gauge with wider measuring range is demanded.

Fifth, pressure sensor and vacuum pump are not the only key components of air permeability instruments, precision and measuring range of flow meter are also very important.

Sixth, for different materials, the difference in testing standards and testing methods also cause great difference in the units of testing data. For example, the unit of final testing results of textile is gas permeability (mm/s), while the unit of that of the leather is permeability quantity (ml/cm²·h). With the help of professional operating software, the same instrument can complete data conversion of the above mentioned testing.

At present, there has been a great unbalanced development of air permeability instruments. For example, air permeability testers for textile, paper and so on are abundant in types, while that of polyurethane foam plastics and porous elastic materials are very rare. TQD-G1 Air Permeability Tester developed by Labthink this year is the instrument simultaneously possesses the modes of testing differential pressure by fixed flux and testing flux by differential pressure. Moreover, Labthink can manufacture instruments according to required testing range and testing precision from customers. Such instruments are more superior in actual utility.

3. Conclusion

In gas permeability testing of materials, property difference of the materials will result in obvious difference of testing instruments. Selecting corresponding instruments according to testing requirements is the optimal way to obtain practical testing range and testing precision. Although there are specific testing instruments on sale for materials of flexible package, cigarette paper, textile and so on, the development of TQD-G1 Air Permeability Tester is no doubt a favorable factor in promoting auto gas permeability controlling of materials such as polyurethane foam plastics, porous elastomer and so on.