

## Present Situation and Trend of Permeation Testing

**Abstract:** this article introduces the present situation of permeation testing, and evaluates on the hotspot as well as the prospect of the permeation testing. Meanwhile, this article proposes some hints on how to select instruments.

**Key Words:** permeation, precision, measurement, instrument selection, measuring range

With the strengthening of testing on food and pharmaceutical packaging materials, the promotion of permeation testing has found favorable opportunity. After several years of development, the number of qualified permeation testing labs has increased from very few to several hundred. Not only the number of instruments, but the detailed testing items as well have been greatly broadened. At the same time, there has been great focus on the relationship between permeation testing of packaging materials and the shelf-life of the finished products. Therefore, permeation testing has been greatly strengthened by the manufacturers.

### 1. Present Situation

At present, the common instruments for permeation testing are of differential pressure method for gas transmission rate testing and weighing method for water vapor transmission rate testing. Besides, equal pressure method for gas transmission rate testing and electrolytic method for water vapor transmission rate testing have also found a certain portion of applications.

### 2. Main Focuses

Firstly, market should evaluate the precision of the instruments scientifically with a positive forward-looking view. The testing precision of the instrument depends on the sensors. The precision and stability of instruments on the same testing method work differently in different time periods. Therefore, evaluation based on the testing results of only one certain period is wrong. For example, with the great progress made in pressure sensor and weighing sensor development during the recent one or two decades, the precision of differential pressure method and weighing method has achieved a historical height. However, some reports neglected this point when citing documentations, and still follow the evaluations in the past century on instruments of those two methods, which do not comply with the actual situation. It's sure that with the continuous precision development, human interference on the testing data has become more prominent. The experiences and skills of the instrument operators would sometimes become the key factors influencing the data stability and repeatability.

Secondly, the focus of instrument selection. Some users, when selecting equal pressure instruments and sensor method instruments, concern especially whether the sensor of the instrument is a absolute value sensor or a relative value sensor. (Absolute value sensor includes coulometric sensor and electrolytic water vapor sensor; relative value sensor includes electrochemical sensor and infrared water vapor sensor.) The author holds that such kind of instrument selection habit is improper which would mislead their attention to some individual components. On the contrary, the author thinks the complete performance of the instrument should be the top concern. As to application, absolute value sensor and relative value sensor are equally well. The author disagrees that some promotional material says the life span of electrochemical sensor is short. The author has long been experimenting with electrochemical sensor oxygen permeation testers, and the testing specimens are of varied permeation properties. According to actual use in recent years, it's out of question that the sensor can work stably for more than 3 years (much longer than the description in some reports), only if the users operate normally without

operational errors. Furthermore, the life span of absolute value sensor is relatively short which can be further proved by the newly issued standard.

The author has the following suggestions on the permeation instrument selection: first, the measuring range of the instrument should be based on the permeability of the applied materials in production. Usually, the lower limit of the permeation instruments can meet the testing demands. Therefore, lower limit should be especially concerned. Second, the decision to buy instrument of equal pressure method or sensor method should be in accordance with the permeation property of the material to be tested. It might be fatal for those consuming sensors to test mediate and low barrier property materials. Third, the data repeatability and stability of the instrument should be taken into consideration. Usually, for testing institutes with uncertain specimens, it's necessary to choose instruments (usually, differential pressure method and weighing method) with broad measuring range and reasonable precision; for labs and enterprises with limited funds, differential pressure method instruments and weighing method instruments are also recommended since they are relatively universal.

Thirdly, how to apply measurement authentication for the permeation testing instruments has always been the concerned by the quality inspection labs. Permeation property testing instruments are different from traditional mechanical and chemical testing instruments. For permeation property testing instruments, standard substance is the best method, that is, to inspect and calibrate with films or sheets (commonly termed as reference film) of standard transmission rate. Some information says only the N.I.S.T. can provide such kind of films, but when the author contacts N.I.S.T. directly, there is no such kind of film from N.I.S.T. Therefore, using film to calibrate permeation testing instruments can only be regarded as the company method, not a means for calibration. Take gas transmission rate testing instruments as an example, pressure sensor, temperature sensor and humidity sensor can be measured respectively. Whereas, the equal pressure instruments, no matter absolute value sensor or relative value sensor is applied, can only be measured by standard gas sensor. Thus, it should be noted that the instruments that cannot be calibrated with standard gas will be in trouble when inspecting and calibrating. Multi-spot calibration using multi standard substances is a common measuring method, and is widely used in mechanical, optics, chromatography and other technologies. Multi-spot calibration is accurate and objective, with can greatly lower the calibration failure rate.

### 3. Future Prospects

There has been great development of permeation testing instruments in testing precision and testing method. And, with the further expansion of permeation testing field, with the stricter testing requirements, the future prospects of permeation testing are as follows:

First, special permeation testing instruments for different industries will be developed. Now, one type of instrument is commonly used in different industries. The introduction of special instrument will change the present status of low professionalization. With the extending of material permeation application, permeation testing is no longer limited to packaging industry, and has found testing demands for materials in automotive, textile, medical, construction, aviation and electronics, etc. Moreover, permeation indexes have become the basis for material selection. However, the material permeation property testing is not identical to packaging material property testing caused by different testing institutions, testing conditions, instrument measuring ranges (e.g., the gas transmission rate of packaging materials and textiles may differs millions of times) and formulas. Therefore, it is a trend to develop special permeation testing instruments according to different needs.

Second, more permeable substances will be expanded. Originally, the permeation testing includes routine gases and water vapor permeation testing. However, with the expansion of research areas, specialty gas transmission rate testing has been the new frontier in permeation testing. There have been great testing demands for organic

gases, explosive and dangerous gases and inert gases. Some of the specialty gas testing has realized by way of improvement of the differential pressure method instruments. As to gases with characteristics different from routine gases, or dangerous gases, special testing instruments should be developed. Therefore, the extension of testing substances is another trend for permeation instruments.

#### **4. Conclusions**

Now, the indexes of permeation testers can satisfy requirements for packaging industry completely, and have made great progress in container package testing. At the same time, new technologies and new methods have been applied increasingly, with only a few notable issues in instrument selection and application. Development of special testing instruments and expansion of testing substances are the two tendencies in the permeation testing field. It's foreseeable there will be extensive and bright future for permeation testing.