Permeability Testing for Super Therm® Coating

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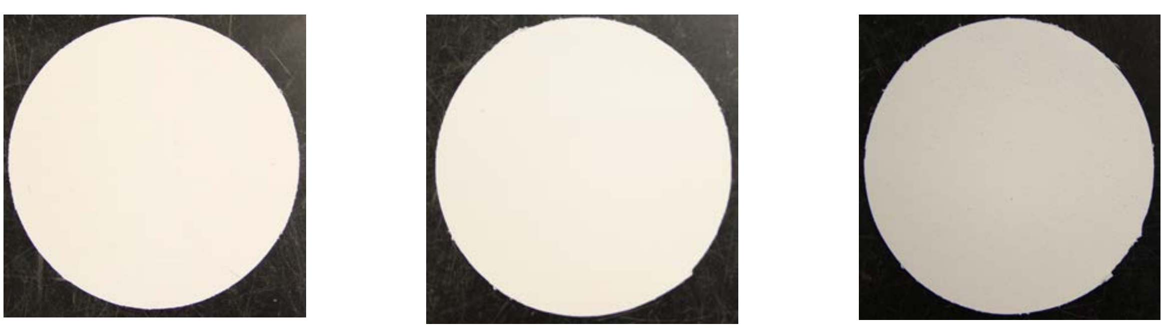
1 Introduction

This report documents permeability testing data and results for a sample of Super Therm® coating material. Permeability testing was conducted to determine the rate at which water vapor passes through the coating material. Southwest Research Institute® (SwRI®) was provided the coating material by Superior Products International. Several test films were prepared from the coating material. After the films had cured, they were each cut to the dimension needed for the test. A separate permeability cup was used for each film. The films were placed on top of the permeability cups. A desiccant material was placed into the permeability cup below the test films. The cups were sealed and placed in a chamber that maintained the temperature and humidity at a certain level. The cups were kept in the chamber for 21 days, except to be taken out every 24 hours for weighing. The test data was analyzed to estimate the permeability of water through the coating.

2 Permeability Testing Data and Results

The testing was conducted per ASTM standard D1653-13 and E96/E96M (Standard test methods for water vapor transmission of organic coating films). Southwest Research Institute® (SwRI®) received the Super Therm® coating material, which was in the form of a slurry mixture. The material was placed in a speed mixer cup that was rotated at 2060 rpm for 60 seconds to degas (prevent bubbles) the film. The coating material was applied to four glass plates, each with two shims mounted on both sides of the plates. A Teflon bar was used to spread out the material between the shims. After 65 hours of curing at room temperature, the glass plates were placed in an oven at 40 °C for 4 hours. The films were removed from the glass plates and were cut with a knife to the size needed for testing. The films were labeled A, B, C, and D. Films A, B, C, and D had an average film thickness of 0.30, 0.25, 0.29, and 0.36 mm (12, 10, 12, and 14 mils), respectively. All four films had a diameter of 74.6 mm. The films A, B and C were selected for the test. Figure 1 shows images of the A, B, and C films that were used .

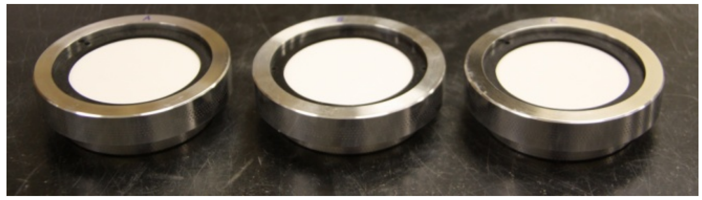
In accordance with the standard Dry Cup method in ASTM D1653-13 (ASTM International, 2013) and ASTM E96/E96M-14 (ASTM International, 2014) , a desiccant was placed in a permeability cup to within 0.25-inch of the top edge. The desiccant used was anhydrous calcium chloride. Each test film was placed above the desiccant and then clamped to the permeability cup using the cup's lid, which was screwed to the bottom flange of the cup. Figure 2 shows the permeability cups used in the test. Initial masses of the permeability cups with film and desiccant were recorded. The cups were placed in the humidity chamber, which was maintained at 23 ± 0.6 ºC, and 50 ± 2% relative humidity. The cups were taken out of the humidity chamber every 24 hours to record the mass, for 21 consecutive days.



(a)Test Film A **(b) Test Film B** **(c) Test Film C**

Figure 1. (a) Test Film A cut out, (b) Test Film B cut out, and (c) Test Film C cut out

(a) Permeability Test Cup



(b) Assembled Permeability Cups with Films

Figure 2. The (a) Permeability Test Cup and (b) Assembled Permeability Cups with Films

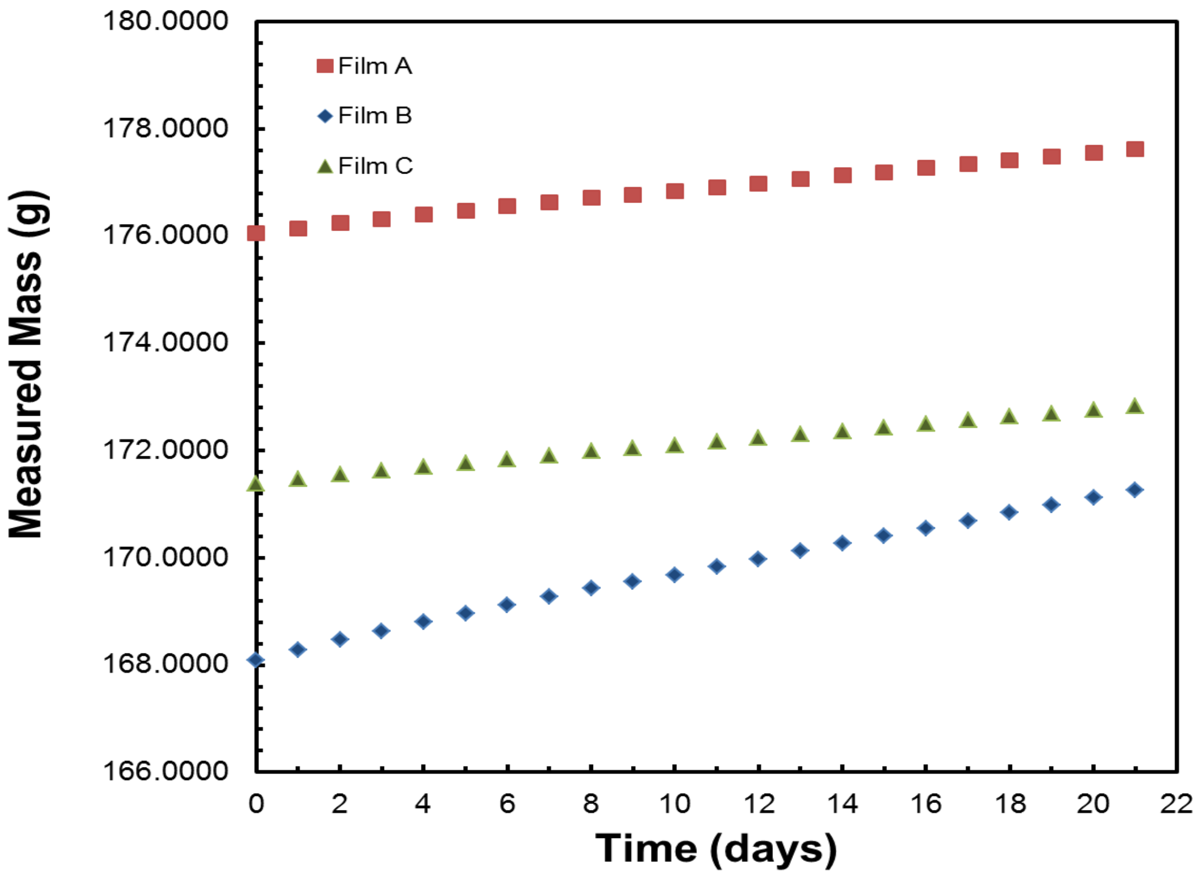


Figure 3. Mass Data for the Super Therm® Films Used in the Permeability Test

The measured mass data for the three films is graphically presented in Figure 3. The mass data is used to estimate the permeability of the three films. A linear regression fit was used on the mass data. The result line that was fit to the mass data was used to determine which data points were closest to the line. The following equation was used to estimate the water vapor transmission rate through the film:

$$WVT = (G/t)/A \tag{1}$$

where

WVT — water vapor transmission rate
G — mass of water transmitted through the film during t
t — time
A — exposed surface area of the film

The above equation was used to estimate the permeability values in the units of (i) grains per square foot per hour, and (ii) mass per square meter per day. The permeability values were also calculated in units of perms, according to the following equation:

$$Permeance = WVT/[S \times (R_1 - R_2)] \tag{2}$$

where

S — Saturation vapor pressure at the test temperature
R_1 — Relative humidity at the source, expressed as a fraction
R_2 — Relative humidity at the vapor sink, expressed as a fraction

In Eq. (2), the saturation vapor pressure at the test temperature is approximately 2810 Pa. In addition, the relative humidity values (expressed as fractions) at the source and sink are 0.5 and 0.0, respectively. The permeability values using Eq. (2) are in units of ng/(m^2-sec-Pa). These values are converted to units of perms, using the following conversion factor: :

$$1\ Perm = 57.2\ ng/(m^2 - sec - Pa) \tag{3}$$

The permeability values were calculated in the following units: (i) grains per square foot per hour, and (ii) mass per square meter per day, and (iii) perms. The estimated permeability values of the three films in the various units are listed in Table 1.

Table 1. Estimated Permeability Values of Super Therm Films A, B, and C

Film	Thickness (mils)	Permeability		
		grains/ (ft^2-hr)	g/(m^2-day)	perms
Film A	12	1.72	1.20	4.16
Film B	10	3.43	2.39	8.26
Film C	12	1.60	1.12	3.86

3 Conclusions

The permeability of Super Therm® for a film thickness of 12 mils is approximately 4 perms; whereas permeability for a film thickness of 10 mils is approximately 8 perms.

4 References

ASTM International. ASTM E96/E96M. “Standard Test Methods for Water Vapor Transmission of Materials” West Conshohocken, Pennsylvania: ASTM International. 2014.

ASTM International. ASTM D1653-13. “Standard Test Methods for Water Vapor Transmission of Organic Coating Films” West Conshohocken, Pennsylvania: ASTM International. 2013.