

VARIABLES THAT AFFECT CALCIUM CHLORIDE MOISTURE TESTING

Rick A. Huntley
KTA-Tator, Inc.
Pittsburgh, Pennsylvania

Abstract. The calcium chloride moisture vapor transmission test has steadily gained acceptance in the floor coating industry. This paper discusses variables that affect the results of moisture vapor transmission testing, and presents the results of testing designed to measure the affects of certain environmental parameters on the results of calcium chloride moisture vapor transmission testing.

INTRODUCTION

It is widely accepted that moisture vapor transmission through concrete floor slabs can adversely affect the performance of coatings that are applied to the concrete slab. Before the early 1990s, it was common to check for moisture vapor transmission (MVT) through a concrete slab using either the plastic sheet method or any of a number of contact probes that were available for testing moisture. The plastic sheet method was strictly a qualitative test. A plastic sheet was taped to the bare floor, and the underside of the plastic sheet was later examined to determine whether moisture had condensed on the sheet. If moisture was found on the back of the sheet, it was assumed that the moisture vapor transmission through the concrete was too great for the successful application of coatings to the concrete slab. The moisture contact probes usually work by measuring the conductivity between two points in the concrete. The probe correlated the conductivity of the concrete to the moisture content and typically had a range that was considered safe for coating.

BACKGROUND

Another moisture vapor transmission test was commonly used in the resilient flooring industry. This method was known as the Calcium Chloride Test. The test was believed to have originated in the 1950s. The test was designed to quantitatively determine the rate of moisture vapor transmission through a concrete floor slab. ASTM International officially approved a calcium chloride test method in 1998 under the designation ASTM F 1869, "Measuring Moisture Vapor Emissions Rate of Concrete Subfloor Using Anhydrous Calcium Chloride."

In the calcium chloride test method, a dish of dried anhydrous calcium chloride is weighed and placed on the floor where the moisture vapor transmission rate is to be measured. The method requires that if a floor coating has already been applied to the concrete, the coating must be removed from an area at least 20" x 20" in size. A sealant is then applied to the flange of a transparent plastic covering, and the covering is placed over the calcium chloride dish. The dish is allowed to remain for 60 to 72 hours. The dish is then removed and re-weighed. The weight gain is assumed to be the result of moisture absorbed by the calcium chloride. The moisture vapor transmission rate is then calculated based on the area under the transparent plastic covering (minus the area of the dish), the weight gain of the calcium chloride, and the exposure time. The moisture vapor transmission rate is expressed in pounds per 1000 ft.² per 24 hours. It

is commonly held that the maximum moisture transmission rate acceptable for application of coatings is 3 pounds per thousand square feet per 24 hours, although permissible rates can vary depending on coating manufacturer's specific requirements.

CALCIUM CHLORIDE TEST VARIABLES

The calcium chloride test is based on the assumption that moisture that is absorbed by anhydrous calcium chloride in a dish on the surface of the concrete slab originated either under a concrete floor slab and migrated through the slab to the surface from directly below, or in the concrete slab itself. In reality, moisture vapor will travel randomly in any direction. As a result, moisture vapor in the air above a concrete floor can travel into a concrete slab. Once in the concrete it is reasonable to expect that the moisture can then travel horizontally. Given this expectation, one would further expect some moisture that is absorbed by the calcium chloride to originate in the air surrounding the transparent covering the dish. The amount of moisture absorbed would increase as temperature and relative humidity increases. Porosity of the concrete near the surface would also affect the absorption rate, since migration through the concrete would increase as the porosity increased.

ASTM Standard Test Method F 1869 provides no limitations on the temperature and relative humidity of the environment surrounding the calcium chloride test apparatus if the conditions approximate the normal operating service environment. The test method simply suggests that the test site should be at the same temperature and humidity expected during normal use. If the temperature and humidity can not be controlled to the range expected during normal use, the test method requires that the temperature should be 65°F to 85°F, and the relative humidity should be 40% to 60%.

When an impermeable coating is applied to a concrete floor, no significant amount of moisture can migrate from the concrete to the air above, nor from the air above to the concrete. The moisture, though, can migrate horizontally under the floor coating. The calcium chloride test method allows testing to be conducted on previously coated floors in areas where a minimum 20" x 20" square of coating has been removed. Since the moisture in the surrounding areas around the 20" x 20" square of removed coating cannot migrate vertically through the impermeable coating, it is a reasonable assumption that some quantity of the moisture will migrate horizontally into the area where the coating has been removed, creating a kind of chimney effect and possibly biasing the results of the calcium chloride test.

MOISTURE VAPOR TRANSMISSION TESTING

In order to determine the effect of the various variables on the calcium chloride moisture test results, two test protocols were developed. The first test protocol was developed to assess the "chimney effect," or moisture migration from areas of the concrete slab covered by an impermeable floor coating to areas where the floor coating has been removed to perform moisture vapor transmission testing. The testing was conducted in a large facility that had been recently constructed with concrete floors and a self-leveling 100% solids epoxy floor coating system. The facility was near completion, and the HVAC system was operational. Four test locations were chosen within the facility. In each of the four test areas, the self leveling epoxy floor coating was removed from a 24" x 24" square, which is somewhat larger than the 20" x 20" square minimum required by the test method. Approximately 24 hours after the coating was removed, a pre-weighed dish of calcium chloride was placed in each test area and covered with a transparent plastic covering. The transparent plastic covering had a sealant applied around the flange and

the sealant was firmly pressed into the concrete to form an airtight seal. After approximately 70.5 hours, the plastic covering was removed and the plastic dish with the calcium chloride was reweighed.

After completion of the calcium chloride testing, all of the floor coating was removed from the facility due to technical problems with the coating not necessarily associated with excessive moisture. The temperature and humidity within the facility was maintained at approximately the same level by the HVAC system. One week after the floor coating was removed, the calcium chloride test was again performed in the same areas at which it had previously been performed. The calcium chloride dishes were allowed to remain in place for 69 hours. The dishes were then removed and reweighed, and the moisture vapor transmission rate was calculated in accordance with the requirements of ASTM F 1869. The following table compares the results of the calcium chloride moisture testing on the floor that had contact coating with a 24" x 24" area removed, and the calcium chloride moisture testing performed where no coating remained on the floor.

Table 1
Moisture Testing Before and After Full Coating System Removal

Test Area	Full Coating Removal MVT lb/1000 sq. ft/24 hours	24" X 24" Coating Removal MVT lb/1000 sq. ft/24 hours	% Increase
Area 1	1.32	3.04	130%
Area 2	1.82	3.63	99%
Area 3	3.97	10.91	175%
Area 4	2.48	4.48	95%

The results in Table 1 demonstrate that there was a significant difference between the moisture vapor transmission rate measured in areas where a 24" x 24" square of coating was removed, and the same area after all of the coating was removed.

The second test protocol involved measuring of the moisture vapor transmission rate using the calcium chloride test on concrete test panels. Two sets of concrete test panels were used. The first set was 16" x 16" x 2" commercially available concrete paving blocks. The second set was 12" x 12" x 1.5" poured normal weight concrete panels. All of the panels were completely sealed on the bottom side and on the edges with approximately 15 mils of an amine cured epoxy. The panels were sealed to prevent moisture migration through the bottoms and the sides. The tops of the panels were lightly abrasive blast cleaned to remove laitance, but left uncoated. The design of the panels allowed for moisture migration through the tops of the panels only, while preventing moisture migration from the bottom and the sides.

The calcium chloride test was performed on each panel while the panels were exposed to various conditions of temperature and humidity. The panels were stored for at least 24 hours at 70°F and 50% relative humidity before the calcium chloride test was performed. Once the calcium chloride test apparatus was attached to the panels, the panels were placed in an environmental chamber. The

temperature and humidity were varied to determine the affect of temperature and humidity on the amount of moisture that could migrate through the top of the test panels.

The first testing was performed on the commercially available concrete paving blocks. Although the blocks appeared to be normal weight for concrete, there was some visible porosity in the surface. The following table presents the results of the moisture vapor transmission testing on the concrete paving blocks.

Table 2
Moisture Vapor Transmission Testing on Concrete Paving Blocks

Test Panel	Temperature (° F)	Relative Humidity (%)	MVT (lb/1000 sq. ft/24 hours)
Panel 1	90	95	19.39
Panel 2	75	50	14.86

As can be seen for Table 2, the moisture vapor transmission rate through top of the relatively porous concrete paving block was considerable, leading to moisture vapor transmission rate measurements much greater then the 3.0 lb/1000 sq. ft./24 hours maximum level generally considered acceptable for coating application to a concrete floor. These high moisture vapor transmission rate measurements were observed despite the fact that the backs of the panels were completely sealed, and no significant moisture vapor could have migrated through the concrete from the bottom.

The rest of the testing was performed on 12" x 12" normal weight poured concrete panels. All the panels were coated on the top and sides, and the top of the panels were lightly abrasive blast cleaned to remove laitance. The following table presents the findings from moisture vapor transmission rate testing on the normal weight poured concrete test panels:

Table 3
Moisture Vapor Transmission Testing on Poured Concrete Panels

Test Panel	Temperature (° F)	Relative Humidity (%)	MVT (lb/1000 sq. ft/24 hours)
Panel 3	75	50	3.22
Panel 4	90	95	5.12
Panel 5*	75	50	3.01
Panel 6	55	70	1.82
Panel 7	75	70	3.47

*Testing repeated at same temperature and humidity as Panel 3.

As can be seen from Table 3, the measured moisture vapor transmission varied considerably and appeared to increase significantly with increases in humidity and temperature. It is interesting to note that the measured values were all greater than the 3.0 lb/1000 sq. ft/24 hours maximum value considered acceptable for application of floor coatings.

CONCLUSIONS

The calcium chloride moisture vapor transmission testing performed in this research indicate that the results are significantly affected by humidity and temperature of the surrounding air, and vary considerably depending on whether the testing is performed on a bare concrete floor, or on a coated floor where a small area of the floor coating has been removed.

The testing has shown that measured moisture vapor transmission rates obtained from testing on a large bare concrete can be less than half the measured moisture vapor transmission rate in the same area when only a 24" x 24" area of coating has been removed. Moisture from surrounding areas of the concrete slab likely migrates horizontally through the slab and to the calcium chloride moisture testing site. Based on these results, it is likely that the measured moisture vapor transmission rate obtained using the calcium chloride test before application of a floor coating will be considerably lower than test performed after the coating has been installed and sections of the coating are removed for testing.

The research also suggests that much of the moisture detected by the calcium chloride test did not migrate through the slab but instead migrated into the concrete from the surrounding air and migrated around the flange of the plastic cover. The research further revealed that the amount of moisture that enters into the concrete from the surrounding air increases with increased temperature and humidity. The moisture migration through the top of the slab is sufficient to produce moisture vapor transmission test results higher than the 3.0 lb/1000 sq. ft/24 hours maximum recommended by many floor coating manufacturers.