Calcium Chloride v. In-situ Relative Humidity

By: George Donnely Testing & Inspections; (Revised 12/11)

A discussion on the differences and Pros & Cons of these two types of moisture testing;

Moisture passing from or through concrete has become the number one cause of floor covering system failure in this country. Most U.S. producers of floor coverings, adhesives and resinous coatings have historically looked to the calcium chloride method of testing concrete slabs to determine dryness and suitability for the installation of their products. The American Society for Testing and Materials (ASTM) has written a standard for the use of anhydrous calcium chloride when testing dryness of concrete. The standard's most current version is also known as ASTM F 1869-11. Some floor covering manufacturers are now either suggesting or requiring the use of in-situ relative humidity data as the preferred method of determining concrete dryness. ASTM has also published a standard test method for the use of in-situ relative humidity probes, the test's current version and designation is ASTM F 2170-11. This test method involves measuring relative humidity levels inside of the concrete slab and finds it's basis in testing commonly performed in Europe. ASTM F 710 offers recommendations regarding the suitability of a concrete slab for the installation of resilient floor coverings based on results achieved by these test methods. This standard states that moisture vapor emission, per ASTM F 1869, should not exceed 3 pounds per 1,000 square feet per 24 hours, unless otherwise specified by the flooring or adhesive manufacturer. The standard continues by stating that relative humidity inside of a concrete slab should not exceed 75%, per ASTM F 2170, unless otherwise specified by the flooring or adhesive manufacturer. There is a growing number of floor covering manufacturers requiring both tests be performed prior to installing floor coverings.

This agency is performing tests by both methods and while neither method can offer a 100% guarantee of long-term successful floor covering installation the following is offered for your consideration.

Before discussing the individual test methods, it is important to note that in our opinion, all existing test methods are capable of being "fooled" under certain conditions. I n example, when a very porous concrete, or a concrete mix design with a high water/cement ratio, is placed without the protection of an effective sub-slab vapor retarder, concrete moisture content and vapor emission can vary dramatically with seasons or other changing conditions. There have been studies published that show an effect of installing floor coverings or coatings with limited permeability is that of increasing moisture content in concrete, when a sub-slab moisture source is available. In example, we regularly see situations in which the new tenant of a building wanted to increase office or production space into areas that were designed to be warehouse floor.

Inexperienced people tested the floor with a calcium chloride test kit, found the results met the criteria required by the selected floor covering manufacturer and recommended that installation of materials proceed. Soon after installation, the flooring or its adhesive system failed and new tests were ordered. The new tests reveal moisture vapor emission levels far higher than the original test results and the inevitable finger pointing ensued. Typically, the concrete surface of an open warehouse floor will become sufficiently dry and reveal moisture vapor emission levels low enough to pass the requirements of a floor-covering manufacturer. However, once covered, moisture content in the concrete may begin to rise and can cause a failure of the floor covering system. We often see

this same issue in residential projects when carpet and pad are replaced with sheet vinyl or wood flooring products. Although we have not yet seen this difficulty when testing with in-situ relative humidity probes, there should always be concern when covering or coating concrete that is not protected by an effective sub-slab vapor retarding membrane. Some floor covering manufacturers specifically require the existence of a sub-slab vapor retarder beneath slab-on-grade concrete when their materials are to be installed.

Calcium Chloride or "Moisture Dome" Tests -

Pro -

1. Results of calcium chloride testing continue to be accepted by most U.S. manufacturers of floor covering, adhesive and resinous coating products for the assessment of concrete dryness and suitability for the installation of their products. As noted above ASTM F 710 contains the statement that concrete can be considered suitably dry when vapor emission does not exceed 3 pounds per 1,000 square feet per 24 hours, when tested in accordance with test method ASTM F 1869-11.
2. Testing is relatively easy to perform, no major investment in equipment is required.

Con -

1. The subject building must be acclimated at or near the temperature and relative humidity levels anticipated during occupancy or use. This is often a difficult requirement to meet on a new construction project. If the HVAC system is not operational at the time of testing a recording hygrometer should be employed to monitor and record ambient temperature and relative humidity levels for comparison to intended occupancy conditions. Significant variance between the test environment and intended use environment should cause test data to be questioned.
2. Some floor covering manufacturers no longer recognize Calcium Chloride test results for determining concrete dryness.
3. The most current revision of ASTM F 1869 specifically excludes Calcium Chloride tests from use on lightweight aggregate concrete. Lightweight aggregate concrete is typically the choice to be placed in suspended metal pans.

4. Calcium chloride tests reflect moisture vapor emission from the surface of the concrete. It has been suggested that the test reflects moisture in only the top 1/4 to 1/2 inch of the slab's thickness. If ambient environmental conditions immediately preceding testing have been extremely dry or wet, the concrete surface may be affected and test results may be skewed accordingly.
5. Testing on an open, or breathing, concrete surface may not reflect moisture deep within or directly below the concrete slab. Once covered by floor coverings with limited permeability, concrete moisture content will equalize within the thickness of the slab. This may mean that a greater volume of moisture will be present at the floor covering/concrete interface after installation is completed than was originally anticipated.[1] 6. "Home-made" calcium chloride test kits are being used and in some cases by very reputable labs. Some of these kits do not meet the apparatus requirements of ASTM F-1869-09 and are delivering questionable results.
7. Too many tests are being set without floor preparation as required by ASTM F 1869. Surface contaminants and residue from paint, adhesive, curing or parting compounds can reduce vapor emission at the test site and produce inaccurate test results. Some penetrating parting compounds (tilt-up construction) or penetrating cure and seal products are difficult to detect and impossible to remove. They restrict moisture release and result in reduced vapor emission test results. It is our experience that some of these products will slowly degrade leading to latent moisture release from the concrete and eventual floor covering system failure.

[1] *Moisture Testing of Concrete Slabs:* When 3 lbs is not 3 lbs.pdf; by Peter Craig and George Donnelly; Concrete International Sept 2006

In-situ Relative Humidity Testing:

Pro -

1. It is our field experience that testing slab-on-grade concrete offers results, which are less impacted by ambient temperature and relative humidity conditions than calcium chloride type tests. Thus generating meaningful data under conditions that may not be acceptable for calcium chloride testing. Concrete slabs in contact with the earth are a heat sink and their internal temperature is affected by both the sub-slab soil temperature and by the temperature of the air space above. Whereas the internal temperature of suspended concrete will be driven by temperature of the air space above and below the slab. It must be noted that ASTM F 2170 states that slabs, which are to be tested should be "at service temperature and the occupied air space above the floor slab shall be at service temperature and service relative humidity for at least 48 hours before making relative humidity measurements in the concrete slab."
2. At least one resilient floor covering manufacturer is now exclusively requiring in-situ RH testing and others are listing it as the preferred test method.
3. Virtually all carpet manufacturers, resilient floor covering manufacturers, adhesive and coating manufacturers accept in-situ relative humidity results as a means of determining concrete dryness prior to the installation or application of their products.
4. Testing performed at multiple depths permits a testing agency to develop a profile of moisture conditions through the thickness of a concrete slab. This information permits the user to make a more informed decision regarding the installation of floor coverings or the need to consider other alternatives.
5. Test results appear to be less impacted by the type of, or lack of, floor coverings in place prior to testing.
6. Testing performed with single-use probes has brought the cost down to a level comparable with calcium chloride type tests.

Con –

1. Testing with re-usable probes requires a substantial investment in tools and equipment, which will limit the number of agencies performing tests with these systems.
2. We are seeing data developed by testing agencies that are not following ASTM F 2170 protocol, particularly with regard to acclimation of the test hole and test probe. Without temperature equilibration of the test site and test apparatus, the data generated may be skewed high or low relative to the direction of inequity, thus rendering data collected misleading or meaningless. In a recent article Vaisala, Inc. made the following statements "A Relative Humidity measurement can vary significantly when there is a difference in temperature between the air (concrete) being measured and the measurement probe. For example, if the probe temperature is 1º C lower than the air (concrete) temperature, you would increase your error by about 3% RH". If someone takes a test probe from a hot or cold automobile and drops it into a test hole for only a few minutes the error factor can becomes enormous and the data collected is meaningless.

It is the opinion of this agency that a combination of these tests, performed concurrently in a subject building, offers the greatest depth of data and confidence in decisions that may be made based on such data. When a single test is specified, it is our opinion that the calcium chloride test is best used as a forensic tool in failure investigations and in-situ relative humidity tests are the best pre-installation predictor of potential moisture related floor covering installation failures. We welcome comments regarding this essay from any and all interested parties. You may call us at (501) 915-0626 or send an e-mail to info@moisturetesting.com.

ACI member George Donnelly is the owner of George Donnelly Testing and Inspections and has more than 25 years of experience in the floor covering industry with positions in sales, management, and as a Director of Technical Services. He is a member of ASTM international and the World Floor Covering association. Along with testing, analysis, and consulting, he offers seminars on concrete moisture vapor emission, covering moisture sources, design characteristics of intrusion prevention, and approaches to slabs on ground.