MOISTURE METER INSTRUCTIONS

The MOISTURE METER is designed to measure the relative humidity of the interior of a concrete slab and give results that are compliant with ASTM F2170 which was adopted in September, 2002. By determining the relative humidity of the interior of a concrete slab you can more accurately predict what will happen when the concrete is covered with a floor covering or coating. If excessive moisture is present in the slab it dramatically increases the probability for a failure of any application that is installed over the concrete surface.

To read the relative humidity of the interior of any material the sensor must be placed in the interior of the material. For concrete slabs, we drill a 7/16" diameter hole the is 40% of the overall depth of the slab when there is a vapor underneath it or when there is an unvented steel pan which is commonly used in multistory concrete and steel buildings.

ASTM F2170 calls for a minimum of three tests per site with at least one test per 1000 square feet of surface area. These are minimum testing standards and performing more tests will provide more data with which to evaluate the concrete subfloor. Excessive moisture may not be uniform throughout the concrete slab that you are testing and finding the wet spots could eliminate expensive warranty repairs several months down the road.

Select testing locations and mark with a permanent marker. **CAUTION: When drilling holes in concrete always determine the location of and avoid drilling into any mechanical or structural system components.** You should ask about electrical, plumbing, radiant heating systems, post-tensioned cables, or anything that could be within 2" to 3" of the surface. It's a good idea to draw a rough diagram of the jobsite and plot the general location of each hole and assign each hole a number. It is also best to select testing locations that are not affected by solar heating.

1. Calculate how far into the slab you will need to drill. The holes will need to be 40% of the overall depth of the slab in order to get an accurate reading where the concrete slab has a vapor barrier on the underside. Typically, the hole will need to be approximately 2 inches deep. 5" x .4 = 2".

2. Drill 7/16" inch holes using a hammer drill in the locations you have pre-marked. Do not use water during drilling.

3. Vacuum each hole and seal the hole with a rubber stopper or duct tape. The hole needs to equilibrate for at least 24 hours (ASTM F2170 requires 72 hours) so that the drying effect of the heat from the drilling does not invalidate the test results. NOTE: These holes should be kept sealed from the ambient conditions in the air above the concrete until all testing is completed by placing a rubber stopper in the hole or by sealing the hole with an impermeable tape.

4. After sufficient time has passed, remove the duct tape and immediately place the sensor into the hole. Adjust the black rubber ring around the sleeve so that the hole is sealed*. If the rubber ring is misplaced or damaged you can use plumber's putty to seal the space at the top of the hole.

   * The failure to properly seal the observation holes and allow them time to equilibrate will result in false positive results. These test results will indicate relative humidity that is lower than the actual conditions in the interior of the concrete and could result in excessive moisture related product failures after the installation is completed. The same false positive test results can be obtained by not allowing sufficient time for the sensor to reach both temperature and relative humidity equilibrium with the concrete.

5. Within several minutes you should be able to take your first reading. **NOTE: It is critically important that the relative humidity sensor of the Meter and the concrete are at the same temperature when you record relative humidity.** Any differences in temperature will induce error in the results. Record the jobsite address, name of technician, date, time, hole location, temperature and relative humidity in the hole, and temperature and relative humidity in the air above the hole using the form provided with your start up kit.

Understanding Moisture in Concrete and Moisture Meters Used to Measure It.

Concrete is made up by mixing an aggregate of varying sizes (sand, gravel, or crushed stone) Portland cement and water. The water and Portland cement mix together to form a new chemical compound that we refer to as paste. This paste is a liquid when it is first mixed together which flows into the spaces that occur between all of the aggregate. A chemical reaction also starts to occur when the Portland cement and water are combined that causes the paste to harden. Any excess water that is originally mixed into the concrete that is not used in the chemical reaction remains as water droplets distributed throughout the paste portion of the concrete. Since this chemical reaction occurs over time some of the residual water trapped within the concrete becomes part of the cement paste as it continues to react or cure. In fact some of this additional water is important to the curing process that gradually increases the strength of the concrete. During the initial curing period (7 to 10 days), additional water must be added to the surface to replace the water that evaporates from the surface or a sheet of plastic is placed over the surface to inhibit surface evaporation. Curing compounds are also sometimes applied to the surface to inhibit surface evaporation.

Any water that remains after curing is substantially completed will continue to evaporate through the exposed surfaces of the concrete. In the case of a floor slab that is poured on an unvented steel pan or a 6 mil polyethylene vapor barrier, only the exposed upper surface can accommodate the evaporation of this excessive moisture. During the period concrete is exposed to an exterior environment this drying is retarded by high exterior relative humidity; rain and snow. It is not unusual to have very high interior moisture levels in a concrete floor slab that is many months or possibly several years old. The water to cement ratio that occurs during the initial mixing is the primary factor that influences the amount of residual moisture contained in the concrete. The amount of water required to chemically react all of the Portland cement is fixed by the quantity of the Portland cement in the mix. As more excess water is trapped in the concrete, the resultant concrete structure is more porous due to the spaces that remain after the water has dried out. It is common practice to add extra water making the concrete "soupy" so that it flows and levels more easily and makes it easier to place the freshly mixed concrete when pouring a floor. Or in the case of high rise construction extra water is added to make it easier to pump the concrete to the upper floors.

Curing vs. drying: Although the terms curing and drying are often used interchangeably, they are quite different. As discussed earlier, curing describes a chemical reaction between H20 and Portland cement which results in a hardened cement paste that surrounds and binds the aggregate together. Curing begins during the initial combining of the ingredients that make up concrete and continues for a great deal of time. The drying process also begins immediately as water evaporates from the exposed surfaces of the concrete after it is poured. Information on the water-to-cement ratio of concrete when it is initially placed is not within the control of those who work in the building after it is closed in and weather tight. This is important information to try to obtain so that we can understand the microstructure of the concrete, but in the real world the records concerning the quantities of materials contained in each batch of concrete are probably not available or reliable. Even if the records are accurate, where is the exact physical location of each batch?

Curing of concrete is a topic of interest for those who are involved in the strength and structural properties of concrete. It is architects and structural engineers who deal with strength and stiffness of concrete during the design and erection of the structure. Back in the real world when you are supplying and installing interior finishes which require that the interior environment conditions are the same as they will be when the building is occupied, the strength and stiffness of the structural concrete is not an area of responsibility or concern. But the amount of moisture contained in the concrete is of vital importance. We have to be able to accurately measure the moisture and then predict its effects.

Measuring moisture content: The traditional method of quantifying the moisture content of materials is as a ratio or percentage which compares the weight of the water contained within the material with its oven-dry weight. The most accurate method of determining moisture content is to take a sample, accurately weigh it and then place it in an oven to remove all of the water without using too much heat that would damage the sample. Next weigh the sample again to determine its oven-dry weight (at 0% moisture content). By subtracting the oven-dry weight from the initial weight we can determine the weight of water that was originally contained in the sample. By dividing the weight of the water by the oven-dry weight we compute a ratio which is the moisture content. It usually takes about 24 to 48 hours at 210 degrees F to properly oven dry a sample. Although the process is fairly straightforward, it does require the destruction of the sample which must be removed from the site for testing to be performed. Moisture content is not as directly usable as relative humidity because we have to figure out how much moisture it takes to affect the floor covering materials we are using.

In Situ Relative Humidity ASTM F2170: Another method of determining the amount of moisture contained within a material is to measure the relative humidity that exists in the interior of the material. This is done by inserting a relative humidity (RH) probe into the material and allowing the probe to reach a temperature and RH equilibrium with the material. If the material RH is greater than normal ambient air RH, we know that the material contains some excessive moisture. When we are using wood materials over a concrete subfloor we can very accurately predict the moisture content of the wood placed in contact with the concrete by using a table that shows the direct relationship between moisture content in wood and the equilibrium it reaches when exposed to specific relative humidity and temperature conditions.

Table 3-4
Moisture content of wood in equilibrium with stated temperature and relative humidity (Wood Handbook)

Table 3-4 Moisture content of wood in equilibrium with stated temperature and relative humidity (Wood Handbook)

Temperature						Moisture content at various relative humidity values														
C	F	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
-1.1	30	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
4.4	40	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.3	13.5	14.9	16.5	18.5	21.0	24.3
10	50	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
15.6	60	1.3	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1
21.1	**70**	**1.3**	**2.5**	**3.5**	**4.5**	**5.4**	**6.2**	**6.9**	**7.7**	**8.5**	**9.2**	**10.1**	**11.0**	**12.0**	**13.1**	**14.4**	**16.0**	**17.9**	**20.5**	**23.9**
26.7	80	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6
32.2	90	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3
37.8	100	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9
43.3	110	1.1	2.2	3.2	4.0	4.9	5.6	6.3	7.0	7.7	8.4	9.2	10.0	11.0	12.0	13.2	14.7	16.6	19.1	22.4
48.9	120	1.1	2.1	3.0	3.9	4.7	5.4	6.1	6.8	7.5	8.2	8.9	9.7	10.6	11.7	12.9	14.4	16.2	18.6	22.0

The recommended relative humidity levels in concrete for wood floor installations are 1) 75% or less for Engineered wood flooring, and 2) 60% or less for Solid wood flooring which are adhered directly to a concrete surface. You should note that when solid wood is installed over concrete, wood flooring industry standards require that a very low permeability vapor barrier should be installed over the surface of the concrete. Although adhesives are often designed to be “water proof” this does not necessarily mean that the adhesive is a proper vapor barrier. In fact most adhesives do not effectively function as proper vapor barriers. The exception to this is a heavy application (at a spread rate of no more than 30 square feet per gallon) of Asphalt adhesive combined with 6 mil thick polyethylene.

Other methods that have been used to measure moisture content in concrete have not proven to be as accurate and reliable as interior relative humidity and the oven test. Some of these devices measure properties that do not accurately correlate with moisture in concrete; some of the tests methods don’t provide quantitative data; and some of the tests only measure moisture that is within 1” or less of the exposed upper surface of the concrete. This means that a positive test result will not accurately indicate whether or not excessive moisture is lurking deep in the interior of the concrete. Research has shown that this hidden excessive moisture equilibrates through the entire depth of the concrete slab once the expose surface is covered with an impermeable coating or floor covering.

Rubber Mat/Polyethylene: A rubber mat or sheet of 6 mil polyethylene approximately 12” x 18” is placed on the concrete surface for 24 to 48 hours to see if any condensation or discoloration develops beneath it. This test is not quantitative in that it doesn’t tell us how much moisture might be present. It can also give a false positive because dryness at the surface can be affected by the ambient atmospheric temperature and relative humidity conditions when the testing occurs.

Pin type/Electrical Resistance: Steel pins are driven into the concrete, and the electrical resistance between the pins is measured with an ohm meter which is then displayed as moisture content on the meter scale. Although this is a very effective method when used with wood, scientific research to establish the correlation between electrical resistance and moisture content in concrete has been shown to be inaccurate. Even if it were accurate to some degree the test would only be useful to the depth of penetration. The most common use of these meters is to simply touch the surface of the concrete with the pins which provides no information on excessive moisture that is present deep in the interior of the concrete.

Non-destructive/Surface meter/Capacitance/Power Loss: This meter is placed on the surface of the material and measures an impedance or electromagnetic field which correlates to the density or specific gravity of the material. This measured density is then compared to the material's predicted oven-dry density, and the difference is considered to be the amount of water present. Inaccuracy develops when the predicted oven-dry density of the material does not match its actual oven-dry density and any error is directly related to the magnitude of this difference in density. This turns out to be a not very accurate method of determining moisture content because of the natural variations in density that exist with wood (+ or – 10%). Concrete can also vary in density based on variability of aggregates, water-to-cement ratio, and any air entrainment that is incorporated into the design of the batch mixture. Here again even if they were accurate to some degree the test would only be useful to the depth of penetration. These meters are generally designed to measure to a depth of ¾" to 1" from the surface of the concrete which provides no information on excessive moisture that is present deep in the interior of the concrete. These non-destructive meters have been very popular because they are simple and easy to use. Unfortunately, easy does mean accurate.

Calcium Chloride (CaCl) crystals: This test is performed by placing a small dish of Calcium Chloride crystals under a plastic dome that is fastened to the bare concrete surface. The crystals are weighed at the beginning of the test then placed under the dome for 48 to 72 hours then weighed a second time at the end of the test. The increase in weight is directly related to the amount of water vapor absorbed during the time the crystals are exposed under the dome. Then calculations are made based on the time of exposure and the change in weight which yields a water vapor emission rate which is stated as "pounds of water per 1,000 square feet per 24 hour period." The results of this test procedure are directly related to the temperature and relative humidity in the area above the concrete during the time of the testing. And here again even if they were accurate to some degree the test is generally only useful in providing information to a depth of ½" to 1" from the surface of the concrete depending on the porosity of the concrete and provides no information on excessive moisture that is present deep in the interior of the concrete. Therefore it can also give a false positive because dryness at the surface is dependent on the temperature and relative humidity conditions when the testing occurs. The awkward aspect concerning CaCl testing is that most flooring and adhesive manufacturers have come to recognize this as the definitive test. The Portland Cement Association (PCA) has published new information concerning CaCl testing versus In Situ Relative Humidity. You should check with individual manufacturers for their recommended concrete testing procedures. But you should be aware that a lot of concrete with acceptable water vapor emission rates before the floor is installed results in catastrophic excessive moisture failures two to four months after the floor is installed. We do not recommend this procedure, and do not sell test kits for CaCl.

Calcium Carbide: This test is used in Europe but not very frequently in the U.S. A small area of the concrete slab is broken out with a chisel and pulverized into a fine dust which is carefully weighed then placed in a pressure vessel with Calcium Carbide crystals. The concrete dust is then mixed with the Calcium Carbide crystals and when the water vapor that is contained in the concrete reacts with the Calcium Carbide, acetylene gas is created which generates pressure within the container which is measured by a pressure gauge. The moisture content of the concrete is then determined by the pressure created. Moisture content is not as directly usable as relative humidity because we have to figure out how much moisture it takes to affect the materials we are using.