

The logo for IFTI (Independent Floor Testing & Inspection) features the letters 'IFTI' in a bold, white, sans-serif font. A red curved line is positioned below the letters, starting under the 'I' and ending under the 'T'.

**IFTI**

THE NORTH AMERICAN  
SPECIALIST IN CONCRETE  
SLAB MOISTURE TESTING

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# Understanding Concrete Slab Moisture

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Presented By:

**Lee Eliseian, President & CEO**

Independent Floor Testing &  
Inspection (IFTI)

# Lee Eliseian

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- 35+ years of experience in the floor-covering industry.
- Member of ASTM F06 Committee
  - Chair of 710 Standard
- Member of ACI (American Concrete Institute)
- Member of ICRI (International Concrete Repair Institute)
  - 710-B Subcommittee Chair
  - ICRI Field Testing Judge
- President & CEO, Independent Floor Testing & Inspection, Inc. (IFTI)



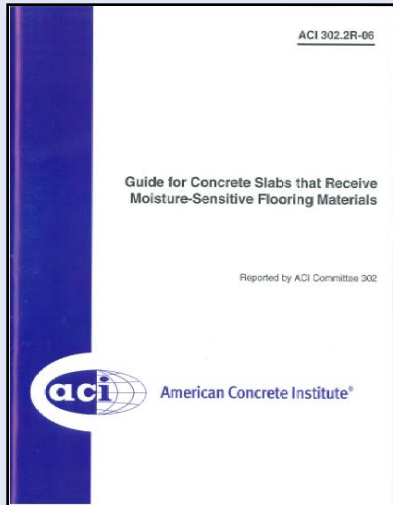
# AGENDA

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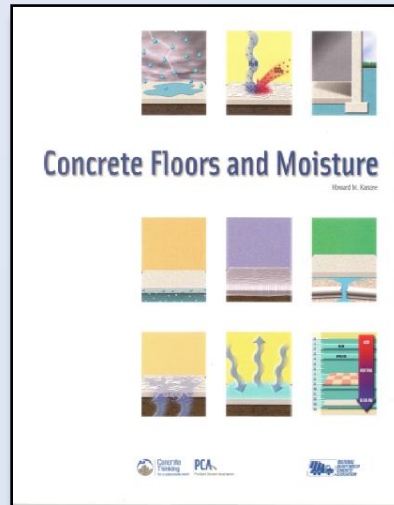
- **Review & Discuss**
  - Concrete slab moisture basics
  - Failures & over-mitigation
  - Industry Trends & Solutions
  - Surface & Internal Moisture Conditions



# REFERENCE MATERIALS



[www.concrete.org](http://www.concrete.org)



[www.cement.org](http://www.cement.org)



[www.astm.org](http://www.astm.org)

# FINANCIAL IMPACT

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- Claims related to concrete slab moisture issues are estimated to cost upwards of **\$1 billion** yearly.
- To put it in another perspective: that's enough cash to purchase the Chicago Cubs!



# GROWING AFFECTED MARKET

## U.S. floor covering market sales volume

(in millions of square feet)

Product sector	2009	2010	2011	2012	2013	% change
Carpet & area rugs	10,601	10,686	10,221	10,197	10,598	3.9%
Hardwood flooring	803	901	1,031	1,097	1,149	4.7%
Ceramic floor & wall tile	1,848	1,992	2,078	2,212	2,406	8.8%
Laminate flooring	912	958	950	964	996	3.3%
Vinyl sheet & floor tile	2,784	2,860	2,579	2,801	3,066	9.5%
Other resilient flooring <sup>1</sup>	280	250	205	201	209	4.0%
Stone flooring <sup>2</sup>	271	260	262	277	294	6.1%

Source: Catalina Research

<sup>1</sup> Other resilient includes cork, rubber, other plastics and linoleum.

<sup>2</sup> Natural stone. Excludes manufactured and engineered stone.

## U.S. floor covering market sales value

(in millions of dollars)

Product sector	2009	2010	2011	2012	2013	% change
Carpet & area rugs	\$9,287	\$9,393	\$9,505	\$9,764	\$10,174	4.2%
Hardwood flooring	1,506	1,784	2,051	2,184	2,446	12.0%
Ceramic floor & wall tile	1,909	2,084	2,210	2,347	2,654	13.1%
Laminate flooring	901	893	894	908	922	1.5%
Vinyl sheet & floor tile	1,818	2,000	1,938	2,195	2,434	10.9%
Other resilient flooring <sup>1</sup>	264	256	229	247	264	6.9%
Stone flooring <sup>2</sup>	1,079	1,062	1,064	1,110	1,186	6.9%

Source: Catalina Research

<sup>1</sup> Other resilient includes cork, rubber, other plastics and linoleum.

<sup>2</sup> Natural stone. Excludes manufactured and engineered stone.

# WHAT IS IT AND WHERE DOES IT COME FROM?

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## Internal Sources

- Free/Batch Water
- Doesn't react chemically.
- Needed for workability and placement.



# WHAT IS IT AND WHERE DOES IT COME FROM?

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## Underslab Sources

- Moisture Travels upwards regardless of water table height.
- Can penetrate slab, depending on presence of vapor barrier





# VAPOR RETARDER LOCATION

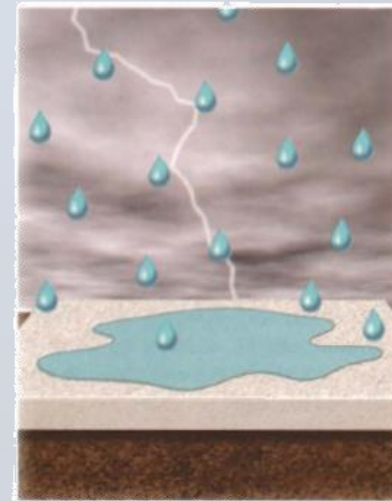


What is the stopping point for moisture vapor?

# WHAT IS IT AND WHERE DOES IT COME FROM?

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- Topical Sources
  - Maintenance
  - Rain/Flood
  - Etc



# WHY IS IT AN ISSUE?

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- In 1992 the EPA required all adhesives be free of chemical solvents.
- This led to water-based adhesives, which are more susceptible to moisture and pH



# WHY IS IT AN ISSUE?

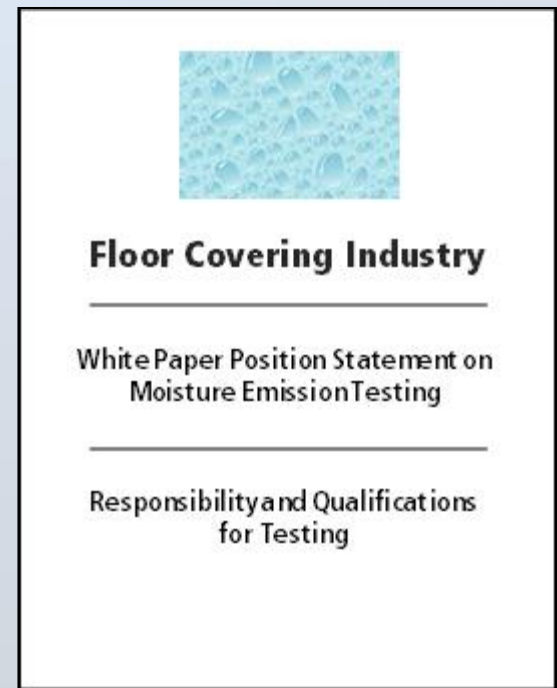
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## Floor covering industry whitepaper

- Originally published by 10 industry associations.
- Updated by FCICA (Floor Covering Installation Contractors Association) in 2013.

## Changes within construction industry

- Loss of solvents
- Increased use of water
- Absorptive aggregate
- Fast track schedules



# WHY IS IT AN ISSUE?

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## Summary:

- Unreasonable Expectations
- Conflicts of Interest
- Lack of expertise

**“It is therefore our recommendation that concrete moisture vapor emission testing be performed by qualified independent agencies. “**



### **Floor Covering Industry**

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White Paper Position Statement on  
Moisture Emission Testing

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Responsibility and Qualifications  
for Testing

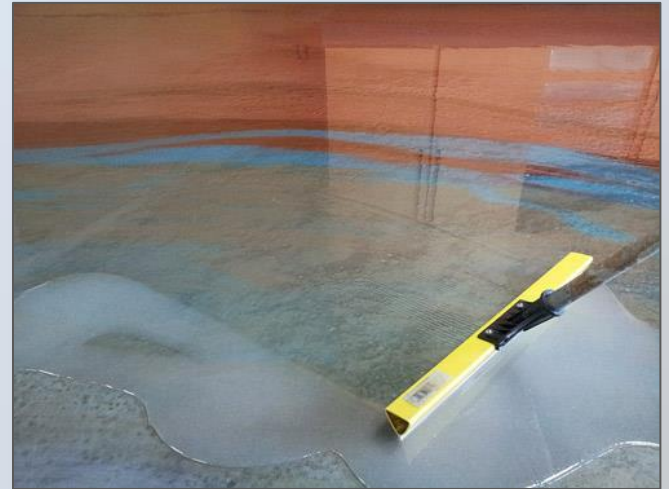
# HOW DOES IT MANIFEST?

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Two ways:



Flooring failure



Over-mitigation

# VISIBLE SIGNS OF MOISTURE ISSUES

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- Adhesive oozing from joints.
- Black lines around tiles.
- Debonded tiles



# VISIBLE SIGNS OF MOISTURE ISSUES

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- Loss of holding strength
- So called re-emulsified adhesive.





# VISIBLE SIGNS OF MOISTURE ISSUES

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- Incompatible patching compounds.



- Osmotic Blistering



# VISIBLE SIGNS OF MOISTURE ISSUES

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- Sulfate Salts

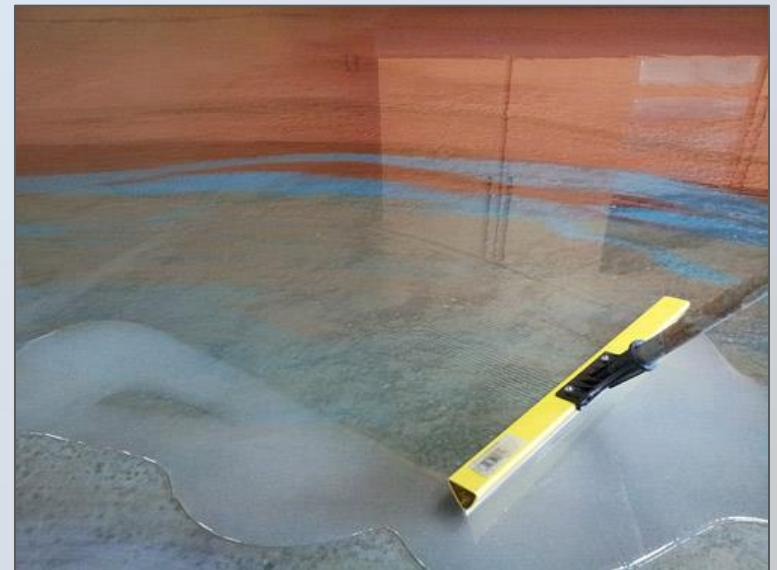


# OVER-MITIGATION

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In some cases, mitigation is necessary to successfully install.

However, unnecessary mitigation occurs often, costing up to \$5/ft<sup>2</sup>.



# WHAT TO DO ABOUT IT

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The first step is to get **reliable information**.

Original Industry Whitepaper:

- It is therefore our recommendation that concrete moisture vapor emission testing be performed by qualified independent agencies.

White Paper Update 2013

- “What hasn’t changed is our recommendation that independent, third party testing companies be contracted to conduct moisture testing in accordance with Industry Standards and manufacturer’s recommendations. “



**Floor Covering Industry**

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White Paper Position Statement on  
Moisture Emission Testing

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Responsibility and Qualifications  
for Testing

# ICRI TECHNICIAN PROGRAM

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“The purpose of this program is to improve the performance of concrete slab moisture testing to result in more consistent, accurate, and reliable results that will help make better decisions.”



# ICRI TECHNICIAN PROGRAM

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## Tier 1

- Educational Program
- Written Exam

## Tier 2

- Educational Program
- Written Exam
- Performance Exam



# ASTM STANDARDS

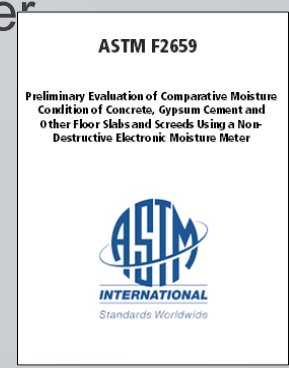
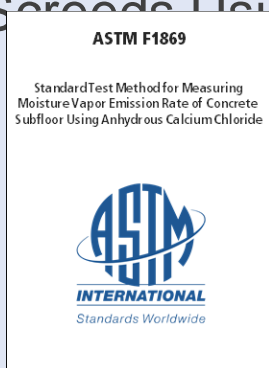
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**ASTM F 1869-11** – Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

**ASTM F 2170-11** – Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using *in situ* Probes

**ASTM F 710-11** – Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring

**ASTM F 2659-10** – Preliminary Evaluation of Comparative Moisture Condition of Concrete, Gypsum Cement and Other Floor Slabs and Screeds Using a Non-Destructive Electronic Moisture Meter



# MOISTURE CONDITION CATEGORIES

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## ***Static:***

- How wet the internal structure of concrete is
- Expressed by percentage
- ASTM 2170 – Relative Humidity (RH) Testing

## ***Dynamic:***

- How much surface moisture is evaporating
- Expressed in pounds
- ASTM 1869 – Moisture Vapor Emission Rate (MVER) Testing

## ***Alkalinity:***

- A measure of soluble salts at the surface
- Expressed by pH





# MOISTURE TEST REPORT



## Moisture Test Report

<b>COMMISSIONED BY</b> Name: Sample Commissioner Address: 1234 Main St. City: City, AZ 12345 Phone: 123-456-7890	<b>PROJECT LOCATION</b> Name: Example Address: 4321 Main St. City: Town, AZ 12345 Phone: 123-456-7890	<b>Moisture Test Report #:</b> P-141039 <b>Report Date:</b> June 30, 2014 <b>P.O. #:</b> <b>Authorized By:</b> Bill Smith <b>Terms:</b> Net 30
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TEST DEPLOYMENT PARAMETERS					NOTES
Date	Time	Temperature	Humidity	Dew Point	See Comment(s) on Last Page
<b>Start:</b> 06/30/14	7:00 AM	73.2° F	43% RH	49.3 F	The "Factor" used to calculate the actual test area of the Calcium Chloride test site: 108.74
<b>Finish:</b> 07/02/14	10:00 PM	74.0° F	52% RH	55.4 F	
<b>Maximum:</b> 75.4° F 53% RH <b>Minimum:</b> 72.9° F 43% RH					The Concrete Slab thickness was observed during field testing to be: 4 inches

**Moisture & Alkalinity (pH) Testing**  
 Moisture conditions for concrete fall into two categories: Static & Dynamic. A Static Moisture Condition is a function of how wet the internal structure of the concrete presently is (usually expressed by percentage). A Dynamic Moisture Condition is a function of how much moisture is currently evaporating from the surface (usually expressed in pounds per 1,000 square feet per 24 hours). An Alkalinity Condition is a function of alkaline and/or other soluble salts that are at the surface of a concrete slab (expressed by pH, the degree of acidity or alkalinity measured on a scale from 0-14). Moisture testing for concrete also falls into two categories: subjective & objective. A subjective, qualitative test relies upon the person testing to make an opinion on the test result and/or condition. An objective test quantifies the result and/or condition in terms of percentage, pounds of emission and pH values. Consequently, the most meaningful tests (recognized by most flooring manufacturers and ASTM) are those that quantitatively produce an objective test result from measuring the Alkalinity, Static and Dynamic conditions of a concrete slab.

**NOTE: Moisture and Alkalinity (pH) testing only reflects the condition of the concrete floor slab at the time the tests are taken.**

TEST RESULTS										Alkalinity Condition			Static Moisture Condition (moisture contained in slab)				Dynamic Moisture Condition (moisture vapor reading from slab)			
Test Locations		Type(s) of Existing Floor Coverings	Visual Distress Level of Existing Floor Coverings	Surface Temp of Concrete	pH Testing ASTM F 710-11	Visual Appearance of Concrete	Concrete Slab Age	Quantitative Relative Humidity in Situ Probe Test: ASTM F 2170-11			Electrical Impedance Test Readings:	Plastic Sheet Test	Mat Bond Test	Quantitative Anhydrous Calcium Chloride Test: ASTM F 1869-11						
Test No.	Area	VCT, OPT, SV	1 to 5	°F	0 to 14	Color	Years	Depth from top of slab, in.	RH in concrete, %	Temp in concrete, °F	0 to 6	Pass/Fail	Pass/Fail	Weight Gain in g.	Exposure Time/hrs	MVER Pounds				
1	Facility	VCT	3	70.4	9	Light grey	8.00	1.6	89.0	73	4.7	n/a	n/a	2.9	63.00	5.0				
2	Facility	Carpet tile	2	70	9.4	Light grey	8.00	1.6	85.0	74	4.9	n/a	n/a	2.6	63.17	4.5				
3	Facility	Carpet tile	2	70.1	9.7	Light grey	8.00	1.6	82.0	74	4.9	n/a	n/a	3.3	63.35	5.7				
4	Facility	VCT	4	71.1	10	Light grey	8.00	1.6	92.1	73.5	5.1	n/a	n/a	3.8	63.50	6.6				
5	Facility	VCT	3	71	10	Light grey	8.00	1.6	92.4	68	4.5	n/a	n/a	4.3	63.67	7.3				
50C	Facility	-	-	-	-	-	-	-	-	-	-	-	-	4.1	63.83	7.0				
6	Facility	Carpet tile	2	70.5	10.5	Light grey	8.00	1.6	96.0	70	5.2	n/a	n/a	4.9	64.00	8.3				

Continues on Page 2...

# TEST DEPLOYMENT PARAMETERS

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TEST DEPLOYMENT PARAMETERS					
	Date	Time	Temperature	Humidity	Dew Point
<b>Start:</b>	06/30/14	7:00 AM	73.2° F	43% RH	49.3 F
<b>Finish:</b>	07/02/14	10:00 PM	74.0° F	52% RH	55.4 F
		<b>Maximum:</b>	75.4° F	53% RH	
		<b>Minimum:</b>	72.9° F	43% RH	

Tracking the environmental conditions of the site is crucial.

# THERMOMETER / HUMIDITY GAUGE

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Leave on site in a central location.

# ASTM PROTOCOL

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## Conditioning:

- Test site should be at “service conditions”
- If not then  $75 \pm 10^{\circ}\text{F}$  &  $50 \pm 10\%$  “range”
- Maintain for 48h prior to and during testing
- Otherwise, results may not be accurate

# MOISTURE TEST REPORT

Moisture Test Report No: P-130319 (Continued)

## Field Testing

We were commissioned to perform Field Testing to determine the following:

- Moisture Vapor Emission Rate (MVER) of the concrete subfloor.
- The pH at the surface of the concrete slab.
- The Percent of Relative Humidity in the concrete floor.

## Analysis

### 1) Dynamic Moisture Condition:

Moisture vapor that is radiating from the surface of a concrete slab. Referencing ASTM Test Method F 1869-11, this test method covers the quantitative determination of the rate of moisture vapor emitted from below-grade, on-grade, and above-grade (suspended) concrete floors slabs.

### 2) Alkalinity Condition:

As moisture vapor passes through a concrete slab, it can collect and condense (turns from a gas to a liquid) beneath a floor covering, at the adhesive bond line. Osmotic forces can compel soluble salts (efflorescence, alkaline salts and/or other contaminants) to the surface from the ground or the concrete itself elevating the pH to damaging levels. Referencing ASTM F 710-11 Appendix X1, Concrete Composition and Practices X1.4 Alkalinity, As Portland cement hydrates, calcium hydroxide and other alkaline hydroxides are formed. The pH of wet concrete is extremely alkaline, typically around pH 12.0 to 13.0. The surface of a concrete slab will naturally react with atmospheric carbon dioxide to produce calcium carbonate in the hydraulic cement paste, which reduces the pH of the surface.

### 3) Static Moisture Condition:

Condense, typically non-moving moisture (Internal Relative Humidity) contained within the body of a concrete slab. Referencing ASTM Test Method F 2170-11, this test method covers the quantitative determination of percent relative humidity in concrete slabs.

## Rules & Standards

Referencing the following standards (copies provided upon request):

- ASTM Designation: F 1869-11 Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.
- ASTM Designation: F 710-11 Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring.
- ASTM Designation: F 2170-11 Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes.

## Application

**Dynamic Moisture Condition:** Most flooring product manufacturers and organizations recommend that the maximum emission rate considered acceptable for moisture sensitive flooring systems is 3.0 pounds per 1,000 square feet per 24 hours, although 5.0 pounds per 1,000 square feet per 24 hours is considered acceptable for some products (based on the Anhydrous Calcium Chloride Test).

**Alkalinity Condition:** (alkaline and/or other soluble salts that are at the surface of a concrete slab): According to ASTM F 710-11 on pH: Readings below 7.0 and in excess of 10.0 have been known to affect resilient flooring or adhesives, or both. Refer to resilient flooring manufacturer's written instructions for guidelines on acceptable testing methods and acceptable pH levels. Most floor covering Manufacturers and Organizations agree that a pH reading greater than 9.0 is a good indication of a potential excessive concrete moisture vapor emission problem.

**Static Moisture Condition:** According to ASTM F 2170-11: The relative humidity in a concrete floor slab shall not exceed 75 % at the time of testing, unless otherwise specified by the flooring or adhesive manufacturer. There are very few U.S. flooring or adhesive manufacturer(s) that have specified maximum acceptable limits for the percent of relative humidity in a concrete slabs as of the writing of this report.

**NOTE:** The internal building envelope / environment conditions in which the slab is located WAS at "normal service temperature and humidity" (during moisture testing). Most floor covering Manufacturers and Organizations agree that moisture testing shall be conducted after the internal conditions of the building in which a slab is located has been at normal service temperature and humidity for at least 48 hours. Otherwise, results may not accurately reflect the amount of moisture which is present in the slab or would normally be emitted from or through the concrete during normal operating conditions. If the service temperature and humidity is unattainable, the internal conditions of the building in which a slab is located shall have been maintained within the following temperature and humidity range for at least 48 hours: Temperature: 65 deg to 85 deg F (18 deg to 29 deg C), and Relatively humidity: 40% to 60%.

## NOTE:

The internal building envelope / environment conditions in which the slab is located WAS at "normal service temperature and humidity" (during moisture testing). Most floor covering Manufacturers and Organizations agree that moisture testing shall be conducted after the internal conditions of the building in which a slab is located has been at normal service temperature and humidity for at least 48 hours.

Please feel free to call for further detail pertaining to any information on this report.

Tested By: Dan Eltseian  
Title: Field Technician

Certified By: James Pouliot  
Title: Certifier

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Site conditions should be noted in the report.

# MOISTURE TEST REPORT

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## **The internal building condition:**

- WAS at “service conditions”
- WAS NOT at “service conditions”, HOWEVER was within the “range”
- WAS NOT at “service conditions”, and WAS NOT within the “range”

# TEST DEPLOYMENT PARAMETERS

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TEST DEPLOYMENT PARAMETERS					
	Date	Time	Temperature	Humidity	Dew Point
<b>Start:</b>	04/19/13	12:30 PM	77.0 F	32% RH	44.7 F
<b>Finish:</b>	04/22/13	12:00 PM	73.6 F	37% RH	45.6 F
		<b>Maximum:</b>	82.0 F	38% RH	
		<b>Minimum:</b>	72.0 F	30% RH	

Knowing the temperature and humidity will allow you to determine the dew point.



# TEST RESULTS

TEST RESULTS				Alkalinity Condition	Static Moisture Condition (moisture contained in slab)						Dynamic Moisture Condition (moisture vapor radiating from slab)					
				Objective Testing	Subjective Testing		Objective Testing				Subjective Testing		Objective Testing			
Test Locations		Type(s) of Existing Floor Coverings	Visual Distress Level of Existing Floor Coverings	Surface Temp of Concrete	pH Testing ASTM F 710-11	Visual Appearance of Concrete	Concrete Slab Age	Quantitative Relative Humidity In Situ Probe Test: ASTM F 2170-11			Electrical Impedance Test Readings	Plastic Sheet Test	Mat Bond Test	Quantitative Anhydrous Calcium Chloride Test: ASTM F 1869-11		
Test No.	Areas	VCT, CPT, SV	1 to 5	deg F	0 to 14	Color	Years	Depth from top of Slab, in.	RH in concrete, %	Temp. in concrete, deg F	0 to 300	Pass/Fail	Pass/Fail	Weight Gain in g.	Exposure Time/hrs	MVER Pounds
1	Sales	VCT	3	72.0	10.9	light grey	20.00	3.2	87.5	73.3	300.0	n/a	n/a	6.0	71.50	9.1
2	Sales	VCT	3	73.0	10.1	light grey	20.00	3.2	86.9	73.8	300.0	n/a	n/a	3.7	71.45	5.6
3	Sales	VCT	3	72.0	9.8	light grey	20.00	3.2	89.0	72.9	300.0	n/a	n/a	3.2	71.42	4.9
4	Sales	VCT	3	72.0	9.7	light grey	20.00	3.2	88.3	72.7	300.0	n/a	n/a	3.2	71.37	4.9
4QC	Sales	-	-	-	-	-	-	-	-	-	-	-	-	3.9	71.33	5.9
5	Sales	VCT	3	72.0	9.6	light grey	20.00	3.2	85.9	73	300.0	n/a	n/a	4.1	71.28	6.3
6	Sales	VCT	3	73.0	10.1	light grey	20.00	3.2	87.8	73	300.0	n/a	n/a	3.5	71.25	5.3



# VISUAL DISTRESS LEVEL

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Level 4 - Severe

Oozing Adhesive Distress



Curling Tile



Oozing Adhesive



# SURFACE TEMPERATURE

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# RELATIVE HUMIDITY *In Situ* TEST

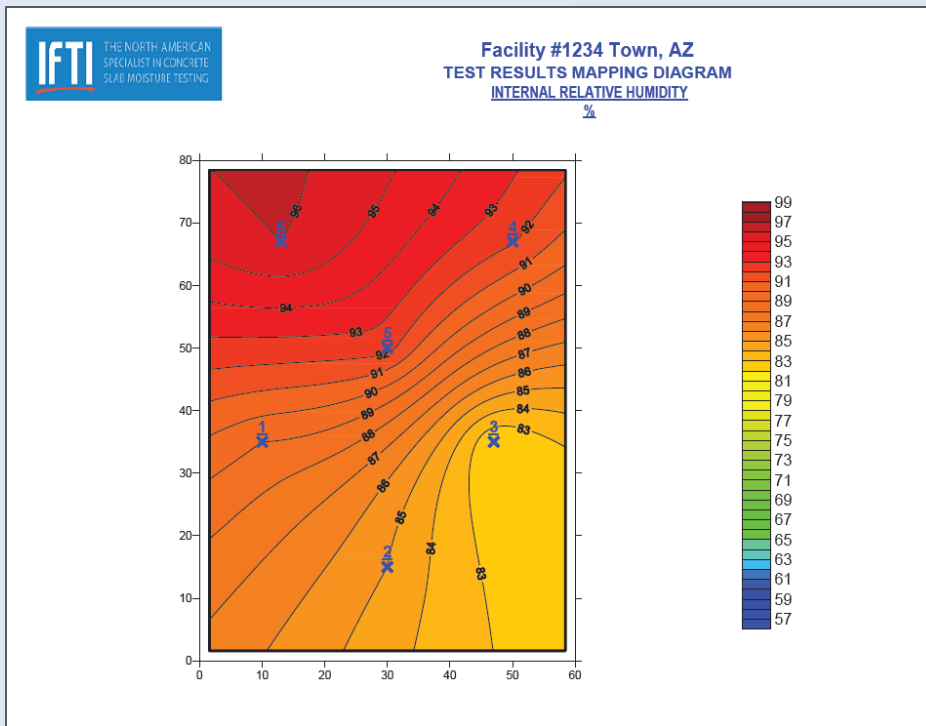
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## ASTM F 2170 Relative Humidity Test



Measures moisture inside the concrete as % relative humidity. Predictor of **future** moisture emission.

# RELATIVE HUMIDITY *In Situ* TEST

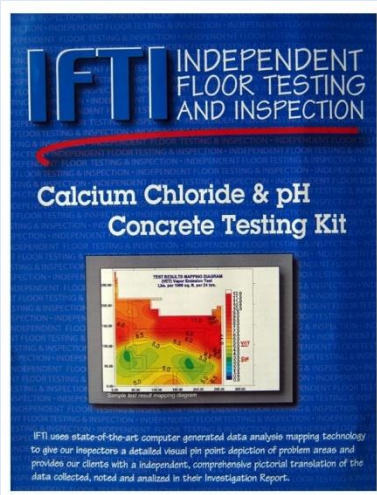


The Test Results Mapping Diagram provides a visual depiction of the numerical values represented over the concrete slab.

# VAPOR EMISSION TEST (MVER)

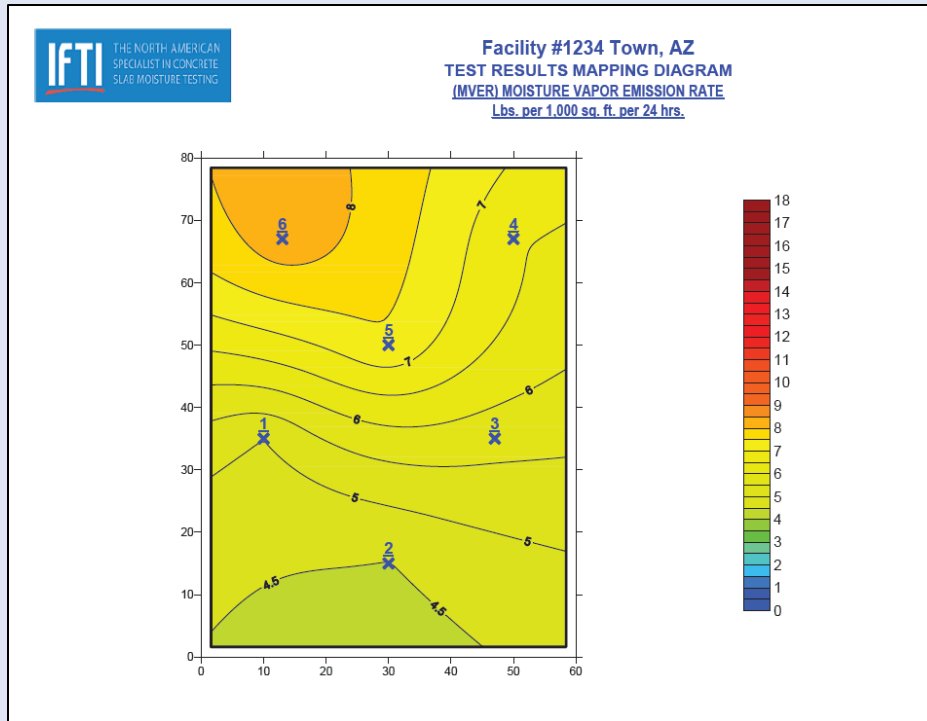
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## ASTM F 1869 Calcium Chloride Test



Measures moisture vapor emissions from **surface** of the concrete.  
as lbs of moisture vapor/1000 ft<sup>2</sup> per 24 hours  
Does not measure moisture deeper than 0.8" below the surface.

# VAPOR EMISSION TEST (MVER)

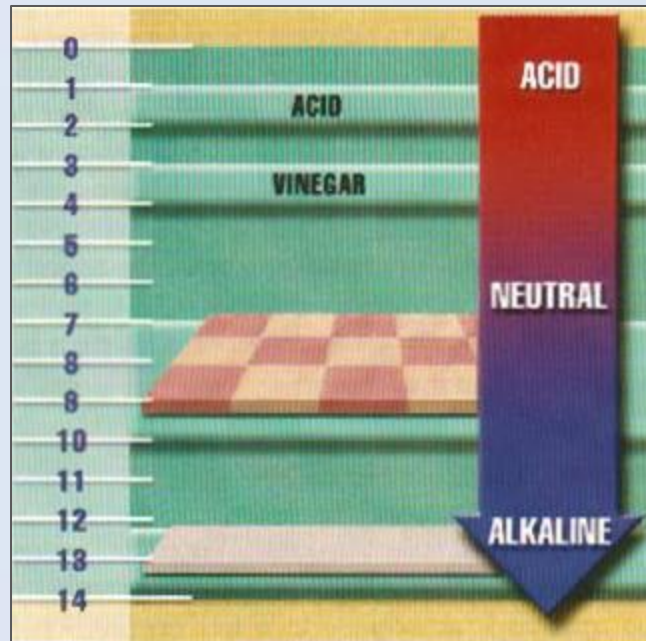


The Test Results Mapping Diagram provides a visual depiction of the numerical values represented over the concrete slab.



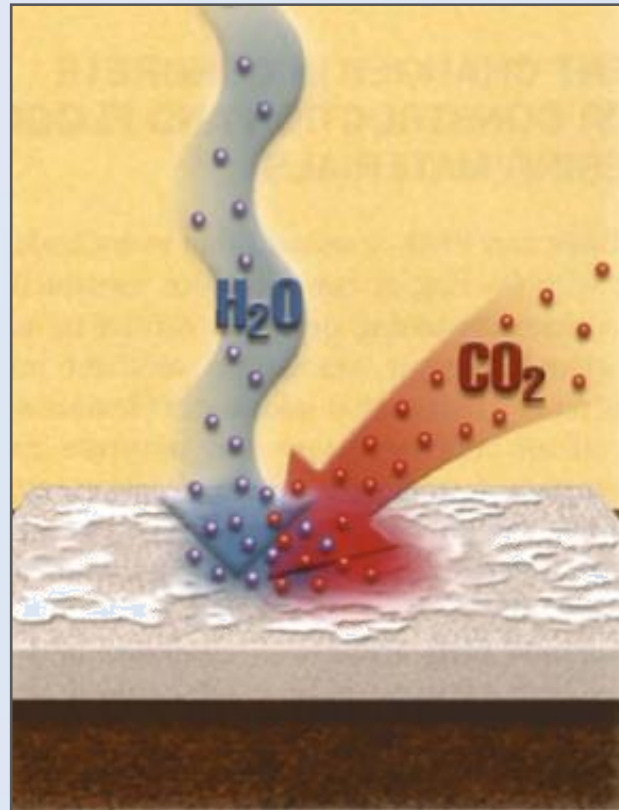
# pH SCALE

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# CARBONATION

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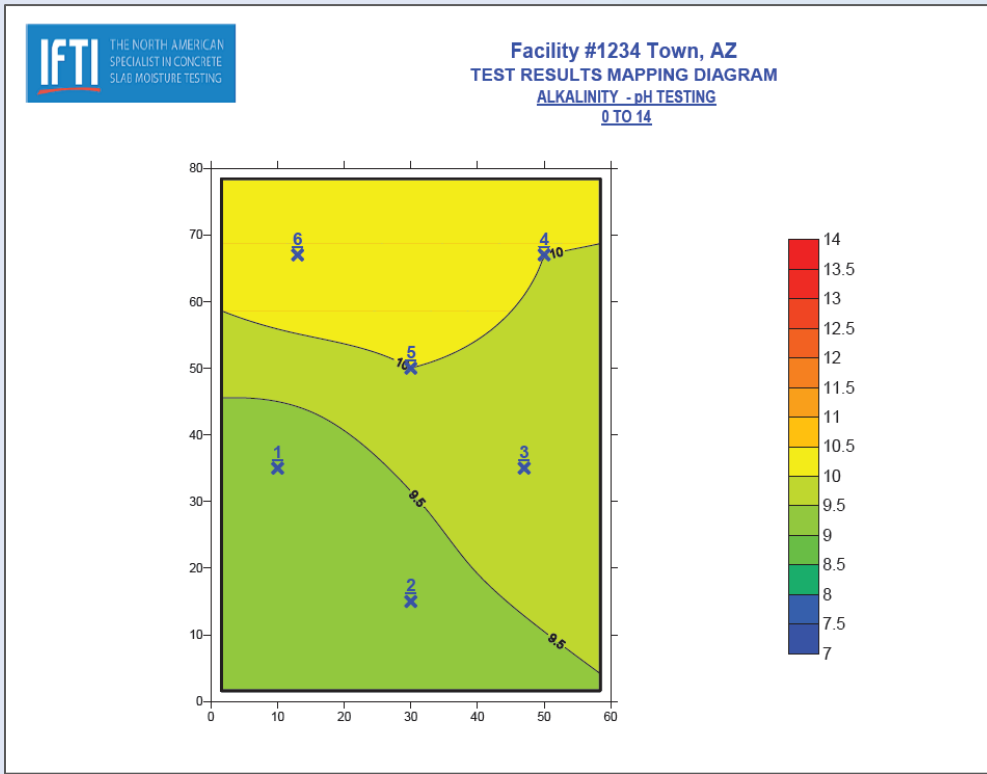


# pH TESTING

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# pH TEST



The Test Results Mapping Diagram provides a visual depiction of the numerical values represented over the concrete slab.

# pH TESTING

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- Testing must be done on a suitable surface
- Inadequately prepared can produce abnormally low result
- Over abrading can produce abnormally high result

# ALKALINITY EFFECT

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- Moisture vapor condenses (gas to liquid)
- Osmosis moves soluble salts to the surface
- Raising pH to damaging levels
- Logarithmic scale (10 times greater)
- Adhesive re-emulsification and bond-failure

# ALKALI ATTACK

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Figure 3-5. Vinyl composition tile (closeup, top) has been attacked and degraded by alkalis carried in moisture rising from below along a sawcut contraction joint in a retail store (arrows, bottom). (IMG15965, IMG16000)

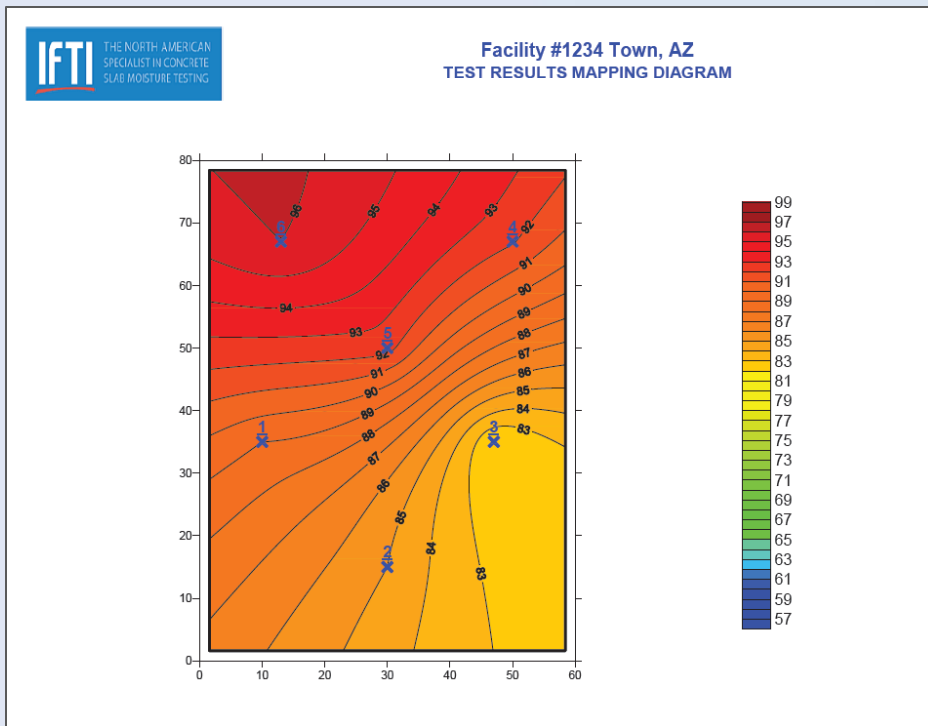
# ELECTRICAL IMPEDANCE DEVICE

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# ELECTRICAL IMPEDANCE TEST



The Test Results Mapping Diagram provides a visual depiction of the numerical values represented over the concrete slab.

# Other Test Methods

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**Plastic Sheet  
Test**



**Mat Bond  
Test**

# TREND TOWARD RH-ONLY TESTING

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- RH testing is a reliable and preferred method for determining moisture content **within** the slab.
- Does not indicate surface conditions.
- Test data shows that many slabs have **high RH**, yet floors are low



# DISTRESS, RH, & MVER STUDY

Moisture Vapor Emission Rate (MVER)						
Distress	Below 5	% Below 5	5.01-8	% 5.01-8	8+	8+
1	8,135	56.05%	4,178	28.78%	2,188	15.07%
2	10,032	46.71%	6,893	32.10%	4,514	21.02%
3	6,938	46.25%	4,748	31.65%	3,296	21.97%
4	1,518	37.59%	1,260	31.20%	1,255	31.08%
5	321	32.16%	363	36.37%	314	31.46%
Relative Humidity						
Distress	Below 80	% Below 80	80.01-90	% 80.01-90	90+	% 90+
1	4,466	30.77%	4,675	32.21%	5,538	38.15%
2	5,940	27.66%	6,748	31.42%	8,788	40.92%
3	4,315	28.76%	4,455	29.70%	6,232	41.54%
4	743	18.40%	1,271	31.48%	2,024	50.12%
5	195	19.54%	280	28.06%	523	52.40%

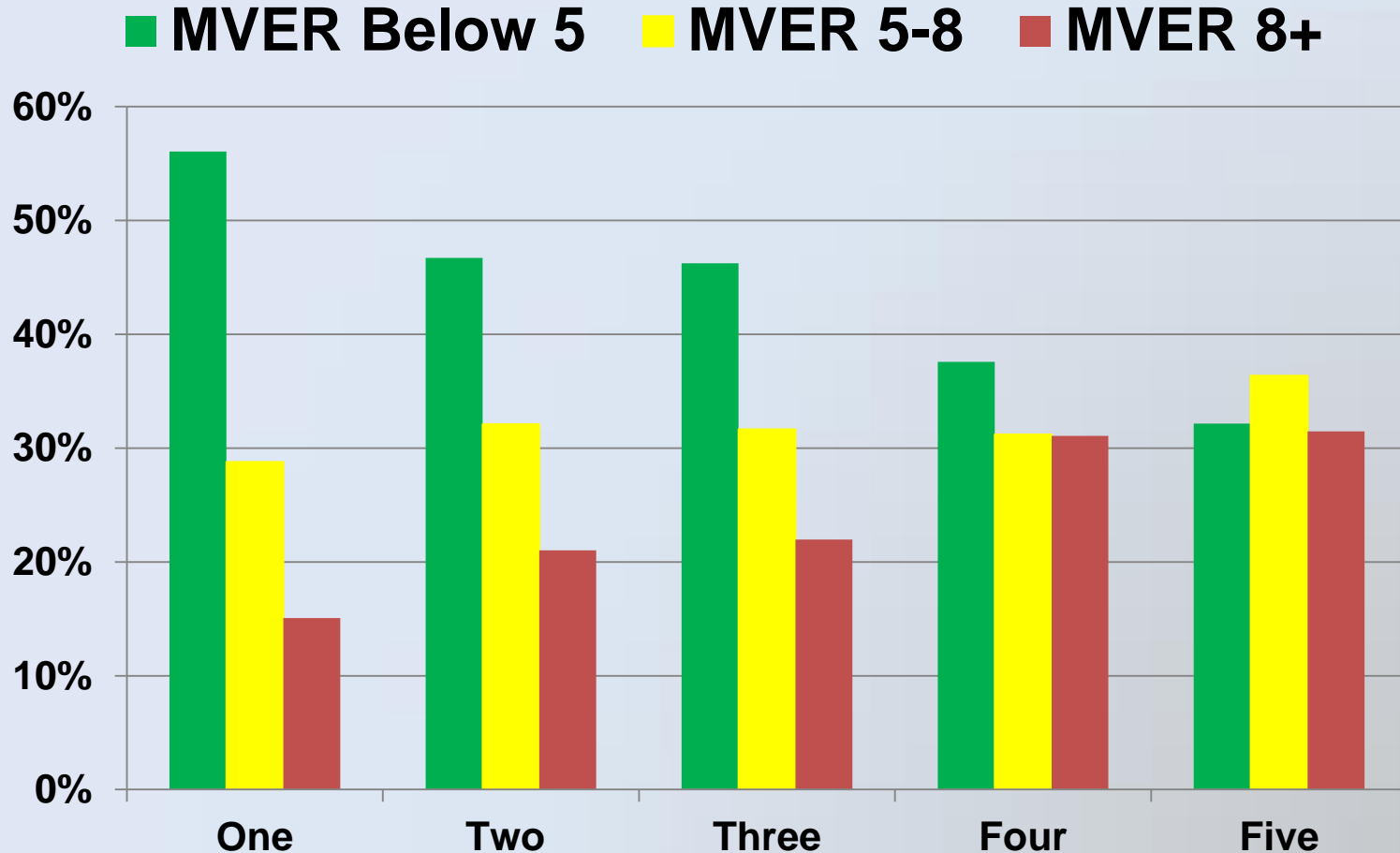
# 56,000 DATA POINTS

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Distress	Total Sites	% of Sites
1	14,515	25.91%
2	21,476	38.33%
3	15,002	26.78%
4	4,038	7.21%
5	998	1.78%
	56,029	

# 56,000 DATA POINTS

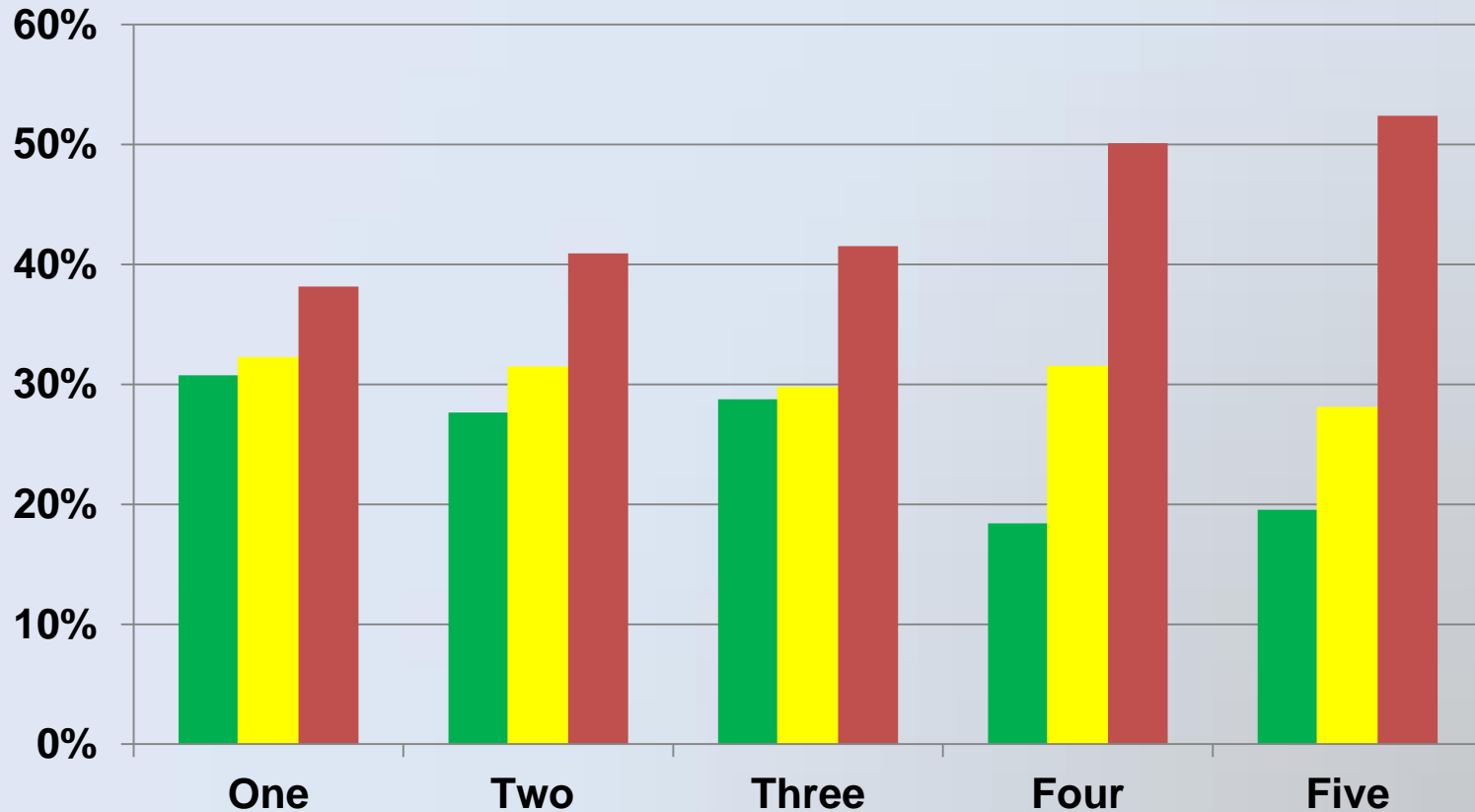
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# 56,000 DATA POINTS

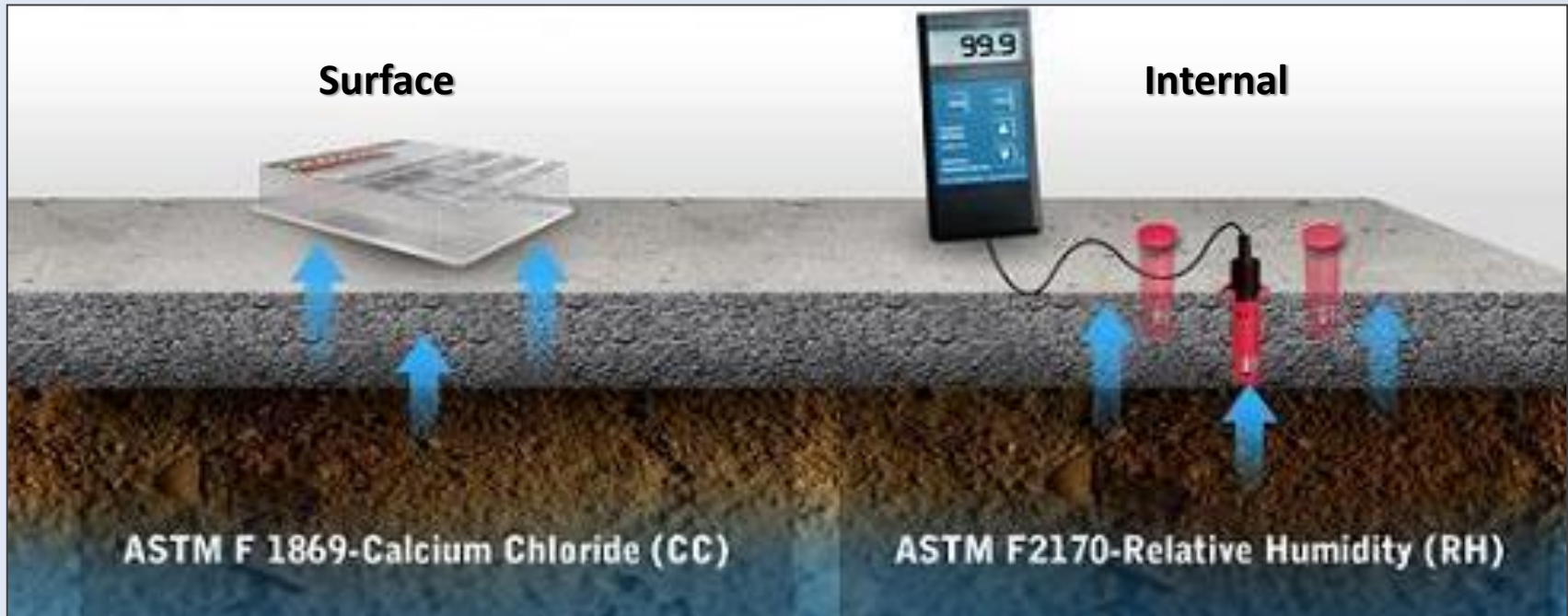
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■ RH Below 80   ■ RH 80-90   ■ RH 90+



# TWO TYPES OF MOISTURE CONDITION

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**As part of a comprehensive survey, you must understand both the internal and surface moisture conditions!**





## Q & A

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Give Lee a business card or email [info@ifti.com](mailto:info@ifti.com) for information on IFTI's upcoming blog series which will take a further look at the heaps of test data we've gathered over the last 17 years.

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