EXPLANATION OF PHYSICAL TEST PROCEDURES

INTRODUCTION:

To better understand the relevance of the test methods used, and subsequent data obtained, for specifying polymer floor and wall coating systems; the following are explanations of the various "standard" or typical physical tests procedures performed.

ASTM (American Society of Testing and Materials) are the most common tests and procedures employed for polymer floor and wall systems. Historically, tests with the alpha designation of 'C' (as in ASTM C-579) are tests performed "aggregate filled" (with 200 mesh aggregates or larger) – for Concrete and mortar designations.

While the designation 'D' (such as ASTM D-695) are tests free of aggregates – usually resin and hardener only; and apply to polymer resin materials including epoxy, polyurethanes, vinyl esters, paints, varnishes, latex, furans, etc.

The following are the most common tests, in no particular order of significance :

COMPRESSIVE STRENGTH

This test indicates the breaking (Yield) strength given a specific polymer 'system' (mixed with aggregate) under compression and expressed in pounds per square inch (psi). A typical floor system, generally has a compressive strength that is slightly higher than the value derived by this test because the polymer floor is relatively thin compared to the test specimen. For comparison purposes, standard concrete floors have a compressive strength (value) of between 3,500 to 5,000 psi. There are two (2) 'standard' test methods for compressive strength of a polymer system :

a. ASTM C-579 is the usual test method for compressive strength of "chemical resistant mortars, grouts, monolithic surfacing, and polymer concretes" – either method A or B depending on size of aggregate.
   - Method A – 1" X 1" cylinders when the maximum aggregate size is #12 or less [based on U.S. Sieve Size]
   - Method B - cast into cubes of 2" X 2" X 2" when the aggregate size exceeds # 12 [based on U.S. Sieve Size]

b. ASTM D695 test method for compress properties of rigid plastics is the test method usually employed for resin and hardener system without aggregate.

'COMPARITIVE' TYPICAL COMPRESSIVE STRENGTHS

Concrete Slabs	*3,500 to 5,000 psi*
Urethane Mortar Flooring	*7,500 to 8,500 psi*
1/16" to 1/8" Broadcast Quartz Flooring	*8,000 to 12,000 psi*
¼" Epoxy Mortar Flooring	*10,000 to 12,000 psi*
Resin / Hardener Components ONLY	*12,000 to 15,000 psi*
Hi-Impact Epoxy Mortar Flooring	*14,000 to 16,000 psi*

TENSILE STRENGTH

This is the breaking or cohesive strength of a specimen, expressed in pounds per square inch (psi), when the material is pulled apart. It is not generally considered as important a test as compression strength since floors are not typically subjected to tensile stress or similar 'pulling' exposures. And even though concrete is the most common industrial floor material, standard concrete has very poor tensile strength (in the range of 250 to 400 psi).

a. Materials installed at ¼" or thicker are made into briquette specimens ("Bow Ties") and are tested in accordance with ASTM C-307 – Test Method for Tensile Strength.

b. Materials installed at less than ¼" thickness are cast into flat bars 1" X 1/8" X 8" long and are tested in accordance ASTM D-638.

c. Alternate test methods for tensile strength (elongation) -
   - ASTM C2370 "Test Method for tensile properties for organic coatings"
   - ASTM D-412 "Test Method for Vulcanized Rubber and Thermoplastic Elastomers"

MODULUS OF ELASTICITY (TANGENT)

The modulus of elasticity is a calculated value based on the ratio of the breaking strength (Flexural Strength) in pounds per square inch, compared to the deformation (inches per pound) at break, with the value expressed in pounds per square inch (psi). It is a number used by engineers and architects which indicates the relative rigidity and strength of various materials. For example – steel has a modulus of 30 million ($3.0X10^7$) psi, concrete a value of approx. 3 million ($3.0X10^6$) psi, and typical resilient flooring materials have much lower values in the range of 10,000 to 1,000,000 psi ($1X10^5$ to $1X10^6$). Extremely flexible materials would fall below this range and would be poor candidates as a flooring material.

- The value is calculated in accordance with ASTM C-580 test method.

FLEXTURAL STRENGTH

This test measures the maximum strength it takes to break the material in bending or deflection mode. It is a load applied to the center of a suspended bar of material and is expressed in pounds per square inch (psi). Flexural strength can be very important in relation to the rigidity of the substrate to which it is applied. A material (system) being installed over a concrete substrate does not require the same flexibility that may be required when applied over a wood or steel deck (substrate).

a. Material installed at ¼", or thicker, are cast into 1" X 10" bars in thickness from ¼" to 1" and tested in accordance with the ASTM C-580 test method.

b. Materials installed 'thinner' than ¼" thick are cast into flat bars (dimensions are given in Table I of ASTM Method D-790) and vary in size depending upon thickness of floor system. The test is conducted in accordance with ASTM D-790 test method.

COEFFICIENT OF THERMAL LINEAL EXPANSION

This test measures the changes in length (due to expansion & contraction) typically associated with fluctuation in temperatures. All flooring materials expand or contract as temperatures rise and/or fall. The important factor is that the coefficient of thermal-linear expansion of the material (floor system) should correspond to the coefficient of thermal-linear expansion of the substrate to prevent separation or 'dis-bonding' of the floor material from the substrate. A properly designed polymer floor 'system', when applied at the proper thickness and incorporating the correct blend of aggregate (aggregate load), can be extremely compatible to the coefficient of thermal-linear expansion of a concrete substrate – as an example.

Values for this test are expressed as - inches of change per inch length per degree Fahrenheit (in./in.^{0}F). The test is conducted in accordance with ASTM C-531 test method for Linear Shrinkage and Coefficient of Thermal Expansion of chemical resistant mortars, grouts, monolithic surfacing, and polymer concretes. *[NOTE: The value is usually very small, it is generally expressed as a 'number' times a negative power of ten - i.e. - 0.00000625 in./in. ^{0}F becomes 6.25 X 10^{-6} min./in. ^{0}F].*

MOISTURE [WATER] ABSORPTION

This test indicates the tendency of how a specific material absorbs and/or 'retain' water. For the purposes of this test, absorption refers to a liquid (water) taken into composite system and adsorption refers to a liquid (water) held on the surface of the composite system. A low value (less than 1.0%) indicates a system that water would run off and the where the surface would dry quickly. A high value (over 5.0%) indicates a system that absorbs a considerable amount of water and therefore would have a tendency to dry quite slowly. The values are expressed as percent of weight gained, when comparing the specimen weighed prior to immersion as compared to the weight after immersion (a loss would indicate a soluble material, one which would be unsuitable as a flooring material). A reasonable limit of how porous a floor material should be is approximately 5% (maximum) absorption.

The material is cast into 2" X 2" x ¼" specimens and run in accordance with MIL-D-3134 Par..4.7.8. or ASTM C413 Test method for Absorption of chemical-resistant mortars, grouts, monolithic surfacing, and polymer concretes.

OIL ABSORPTION

This test is similar in nature (and result) to water absorption and indicates how much oil could be taken in by flooring system components. Oil can cause "swelling" (worse that water absorption) which, if severe enough (over 5%) could cause deterioration and/or delaminating of the floor system.

This test is important for functional or industrial type floors that are exposed to various oils, but has little meaning for more decorative floor systems such as terrazzo floors, because the oil will stain them and ruin the appearance of the floor.

This test is performed similar to the water absorption test, except that the material is immersed in a medium No. 3 (high swelling) petroleum based oil for 24 hours versus water (the type oil as listed in Method 6001 of Standard FED-STD-601). Two (2) values are determined : % gain in weight and % gain in volume- and should not exceed 2%. The test is conducted in accordance with test method MIL-D-3134 Par. 4.7.12.

INDENTATION

This test is a destructive test that measures the ability of a floor system to withstand indentation under a 1" diameter ram (dead load) of 2,000 psi for 30 minutes. Indentation is also used to show if a material is resilient.

- Comparatively, a 135 lb. woman wearing a "spike" heal will impart a load of 3,000 psi for only several seconds at any one spot on a floor, as opposed to a "standing" load in one location for ½ hour. Similarly, the average desk can impress a load of approximately 150 lb. psi, while a 4-drawer filing cabinet exerts only about 10 lbs. psi.

The test measures the amount of indentation at room temperature (approx. 72^0 F) caused by the steel cylinder on the surface for 30 minutes.

It is expressed as either inches or as a percent of the original sample thickness. The test is run in accordance with MIL-D-3134 Par. 4.7.4.

IMPACT RESISTANCE

This test measures the ability of a floor system to resist cracking, chipping or dis-bonding [or loss of adhesion] under an impact load. It is generally run with the material(s) applied to a steel substrate; if the test were run over a concrete substrate ($\pm$ 3000 psi) would require a four inch to six inch thick reinforced sample to hold-up to the test. A quality polymer flooring material typically has a much better impact resistance than good reinforced concrete.

This test is an excellent indication of overall quality of the polymer material and its adhesion capabilities. It is a relative test to the severe abusive conditions that a floor material might experience during actual use. This test measures the ability of the floor to withstand the impact of a 2 lb. ball dropped twice from a distance of 8 feet on the same test specimen. The depth of impression is noted (expressed in inches) along with any notations on the condition of the sample with regard to chipping, cracking, or detachment from the substrate of the specimen.

The test is performed in accordance with test method MIL-D-3134 Par. 4.7.3. or ASTM D4226 test method for impact resistance.

HARDNESS / SHORE A OR SHORE D

Also known as a Durometer test; this test is used to measure the relative surface hardness of a polymer floor and/or wall coating systems using an indentor applied into the material under specified conditions of force and time. There are two (2) basic hardness scales that are used in conjunction with polymer coatings. The Shore A hardness scale typically being used for softer or more flexible surfaces [polyurethanes, elastomers, rubber, plastic, etc.] and the Shore D scale used for harder materials [such as epoxies, urethane mortars, etc.].

- The material is cast into a ¼" thick puck (or several specimen piled up to achieve the required thickness) and run in accordance with ASTM D-2240 Test method and either Shore A or D hardness scales.

ABRASION RESISTANCE

The question exists as to the significance or interpretation of laboratory 'abrasion' tests and their relevance when applied [compared] to practical applications. Abrasion resistance, or wear resistance, testing for floor coating materials is most commonly based on the Taber Abraser test. The Taber Abraser is used for most materials and measures the abrasion of a floor material by a Tabor Abrader Machine with a 1000 gm. load (on each wheel) run for 1,000 cycles using "fresh" CS-17 wheels (unless stated otherwise). The CS-17 wheel is about twice as abrasive as the CS-10 type wheel and is considered to provide abrasion associated more closely with traffic or "underfoot" wear. It is important that the wheels be fresh (or new) for this test as they become less abrasive (wear down) with age and/or use. The total load and the number of cycles must remain constant when performing each test and for each product tested in order to provide comparative and conclusive data. Tested with two (2) 500 gm. wheels will actually provide values less than half that of two each 1,000 gm. wheels and therefore do not provide any comparative data.

- The test measures the abrasion resistance of a floor surface to a set of arbitrary conditions, based on ASTM D-4060 TABOR ABRASER test method "for abrasion resistance of organic coatings by a Tabor Abraser".

- There is an alternate method of testing for abrasion resistance that measures the actual wear of a floor surface when compared to aluminum oxide (80 grit) under an arbitrary set of conditions on a wear test machine, specified in MIL-D-3134 Par. 4.7.10 specifications – this test is not generally used and or accepted due to the wide variables used for comparison purposes.

- ASTM D-3730 is the test method most commonly used for Interior Architectural Wall Coatings.

ELONGATION

This test is typically relevant only with flexible or resilient / "rubbery" type products - materials such as flexible epoxy membranes, joint materials, and/or elastomeric urethane coatings. It is measured in 'elasticity', the amount of stretch that a material has, taken to the point of breaking or tearing; and is expressed in percent of distortion of parallel reference lines.

- The test method is based on ASTM D-75 standard.

ADHESION (BOND) STRENGTH TO CONCRETE

One of the most important function of a flooring system is to achieve adequate adhesion or 'bond' strength to the substrate that it is being applied. The proper test should indicate, in a practical manner, the tenacity of a polymer floor / wall coating system to adhere to the substrate. Since concrete has low has low adhesive (strength) qualities, the tests usually result in 100% failure of the concrete [350 to 400 psi with 'Complete Failure of the Concrete']. There are two (2) reliable and common test methods employed for testing the adhesion qualities :

ADHESION (BOND) STRENGTH TO CONCRETE (Cont'd)

- A common test method is the ACI-503 R 'Pull' test [American Concrete Institute] – which involves bonding a metal 'cap' to the substrate floor then pulling the 'cap' from the surface to derive a value in pounds per square inch (psi).

- The other, very similar, test method is ASTM D4541 – "test method for pull-off strength of coatings using a portable adhesion tester".

NON-SLIP PROPERTIES / CO-EFFICIENT OF FRICTION

This test measures the relative amount of "pull" of a leather heel and/or a rubber heeled shoe before they begin to start slipping (static friction) or to continue slipping (sliding friction) under dry, wet, and oily surface conditions. The values are only relative, but for test evaluation purposes, the test readings are expressed in pounds. The higher the number the greater the resistance to slip – and the test readings are classified as :

0.60 or more	Relatively Non-slippery
0.5 to 0.6	Generally acceptable
0.5 or less	Relatively slippery (unacceptable)

SKID RESISTANT SYSTEMS			
		LEATHER	***RUBBER***
STATIC FRICTION	DRY	0.51	1.03
	WET	1.01	1.08
	OIL	--	0.43
		LEATHER	***RUBBER***
SLIDING FRICTION	DRY	0.73	1.09
	WET	1.01	1.08
	OIL	--	0.43

This test may have limited relevance because of the considerable variances of flooring surface textures that can be achieved due to installation techniques, aggregates, and/or amount (distribution) of the slip-resistant aggregate.

- The test is performed in accordance with MIL-D-3134 Par. 4.7.6 using the "Horizontal Pull Slipmeter" testing machine or equal.

- ASTM D-2047 test method "for static coefficient of friction of polish-coated flooring surfaces as measured by a James machine".

NOTE – AMERICANS WITH DISABILITIES ACT : This act requires a minimum slip-resistance of 0.60 for all floor surfaces. Most products / systems manufactured by ROCK-TRED meet or exceed the minimum requirement.

OTHER RELEVANT FLOOR MATERIAL / COATING TESTS

RESISTANCE TO ELEVATED TEMPERATURES – This test is indicates the effect of elevated temperatures on a flooring system when exposed to changes in temperatures. The specimen is subjected to temperatures of 100^0F, 120^0F, 140^0F, and 160^0F, and the results are expressed as inches or %.

- This test is conducted in accordance with MIL-D-3134 Para. 4.7.4

FLAMMABILITY – This is a test method for determining the rate of "burning" (open flame) and/or the extent and time of burning to a horizontal surface before the flame / burn extinguishes itself.

- The test method is ASTM D-635

FIRE / FLAME RESISTANCE – This test indicates the resistance of the coating to "flame" also known as a "fire tunnel test". The fire classification test is based on National Bureau of Standards – NBS I through V inclusive.

- Alternative test method in MIL-D-3134.

ACCELERATED LIGHT & WEATHER AGING – test designed to simulate exposure to salt water and sunlight, and the result or the changes to the specimen based on specific amount of time and number of cycles.

- Material are tested according to MIL-D-3134 Par. 4.7.15.

ELECTRICAL RESISTIVITY (CONDUCTIVITY) TEST – the test used to determine the resistance of the floor to specific electrical charges, based on NFPA 99 :

- Floors for munitions & chemical plants – 0 to 250,000 ohms.
- Floors requiring conductive qualities – 10,000 to 1,000,000
- Floors for electronic components plants – 1,000,000 to 1,000,000,000 ohms.

MOISTURE VAPOR PERMEABILITY – the test used to determine the rate at which moisture vapor passes through flooring, a film, coating, or a membrane.

- Tested in accordance with ASTM D-1653 Test Method "for water vapor transmission of organic coating films".

DEAD WEIGHT - This test, or information, is of major importance to a specifier, engineer, and/or architect in order to calculate and design the 'dead load weight' of a building.

- Any reasonable method for weighing the components, less any sample 'backing', is usually acceptable.

CRITICAL RADIANT FLUX TEST – Similar to the 'Flammability' test, the test is intended to provide a basis for estimating fire exposure of a flooring system "at flame out", the test is suitable for comparison of various type systems / surfaces.

- Tested in accordance with ASTM E 648-10

FOR ANY ADDITIONAL INFORMATION ON TEST METHODS and/or TEST PROCEDURES, PLEASE CONTACT ROCK-TRED DIRECTLY AT 800-762-8733 or AT www.rocktred.com