DESIGN GUIDE FOR THE APPLICATION OF RAVEN and AQUATAPOXY EPOXY PRODUCTS

DESCRIPTION

Raven Lining Systems offers two lines of solvent-free epoxy coatings and grouts, AquataPoxy™ and Raven® ("**Raven Epoxies**"). These unique high-build epoxy products can be applied to steel, fiberglass, masonry or concrete surfaces where exposure to corrosive and erosive environments could be expected. The thixotropic characteristics of **Raven Epoxies** allow them to be sprayed, squeegeed, or rolled on horizontal, vertical or overhead surfaces providing an impermeable resistant topping.

Raven Epoxies are moisture tolerant, self-priming systems that can be applied at single coat thickness varying from 8 to 250+ mils. Although dry substrates are always preferable for any coating, most of our products will bond very well under damp and adverse conditions. Because most **Raven Epoxies** have the ability to cure underwater, in certain situations they can be exposed to liquids prior to full cure or can even be applied underwater.

This guide provides information regarding the work, materials and equipment required for protection and rehabilitation for the purpose of eliminating infiltration, providing corrosion protection, repair of voids and enhancement or restoration of the structural integrity of the surface by spray-applying a monolithic fiber-reinforced high-build epoxy to the surfaces.

Section 1: SURFACE PREPARATION

As with any coating, proper surface preparation is ***essential*** to ensure maximum and proper adhesion; the purpose being to provide a clean, sound substrate with adequate profile and surface porosity to provide a strong bond between the coating and the substrate. Mechanical abrasion is preferable whenever practical. Generally, rust, latent concrete and other surface contaminants can be removed by high pressure water cleaning, acid etching, abrasive blasting, shot blasting, hand tooling or bush hammering. For small and hard to reach places, hand grinders and wire brushing may be required. If mechanical cleaning is not practical, or oil and grease have had an opportunity to penetrate deep into the substrate, it may be necessary to remove and replace or chemically clean the surface.

More specifically, the following describes some recommended surface preparation procedures for various substrates:

Concrete and Masonry

Standard new concrete (not quick setting, high strength concrete) should be completely cured (10-28 days based upon concrete manufacturer's recommendations and surface tensile strength), clean, dust and contaminant free. Existing concrete must be structurally sound and free of all contaminants. Existing incompatible or poorly bonded coatings, form release, curing compounds, toppings, waxes, oils, greases, etc. must be removed prior to application.

The surface to be coated shall be cleaned and abraded to produce a sound concrete surface with adequate profile and porosity to provide a strong bond between the epoxy coating and the substrate. Generally, this can be accomplished with high pressure water cleaning using equipment capable of 5,000 psi at 4 gpm. Mechanical methods such as high pressure water jetting (refer to NACE Standard No. 5/SSPC-SP12), abrasive blasting, shotblasting, grinding or scarifying may be used to remove previous coatings, laitance and contaminated, disintegrated or chalky material. Detergent water cleaning and hot water blasting may be necessary to remove oils and grease from the concrete. Chemical cleaning, such as acid etching with muriatic acid, can be used in select situations. Care must be taken to remove all residual acid prior to the application of any coating. Whichever method(s) are used, they should be performed in a manner that provides a uniform, sound, clean surface that is not excessively damaged.

Steel

Steel structures being coated to protect against incidental exposure or splash should be prepared as follows: Remove all scale, deposits and soluble salts, round off all rough weld and sharp edges. Remove any weld splatter. Dry-abrasive blast according to Steel Structures Painting Council Specification SP-10. Use only steel grit (G-40 size), steel shot (S-230 size), graded flint, black beauty or equal (30-60 mesh). If reusing abrasives, clean them of contamination before reusing. Do not reuse sand or flint abrasives. Use air with minimum of 200 CFM per blast nozzle at minimum of 100 psi. Vacuum sweep surfaces to remove all dust. Apply the coating as soon as possible to prevent blasted surfaces from rusting. Keep moisture, oil, grease, soluble salts or other organic matter off the surface before coating. Spot reblast and vacuum to remove any contamination.

Steel structures being coated to protect in severe-duty immersion services should be prepared in the same manner as above except blasting may be recommended in accordance to SSPC Specification SP-5 to "white metal".

Section 2: REPAIR AND PATCHING

Repairs and patching necessary for final surface preparation varies from structure to structure. The following outlines summary procedures:

Concrete and Masonry

1. Any area exhibiting movement or cracking due to expansion and contraction shall be grouted and patched according to the appropriate crack repair or expansion joint procedure provided by the manufacturer.

2. All surfaces that show exposed structural steel, spalling greater than 3/4 inches deep or cracks greater than 3/8 inches wide, shall be patched using a quick setting, high strength cement mortar or a high-build, non-sagging epoxy grout after sandblasting steel to SSPC-10. Holes to be filled should be done so in lifts according to manufacturer's recommendations.

3. All concrete that is not sound or has been damaged by chemical exposure should be removed to a sound concrete surface.

4. If, in areas to be patched, reinforcing steel is missing and radial cracking from the spall site exists, the steel shall be replaced unless the project engineer determines that calculations of a new moment of inertia and maximum allowable moment indicate that the replacement product will offset the loss of steel.

5. In masonry structures where loss of mortar has created gaps greater than 1/4 inch in diameter between the bricks or blocks, the voids can generally be filled using a compatible quick setting cementitious mortar. Whenever structural integrity is questioned, a high-strength cement mortar or epoxy grout should be utilized.

6. (Underground Structures) Surfaces shall be free of active leaks before coating. Leaks may be stopped with the use of approved quick setting hydraulic cement, water reactive gels and grouts, epoxy grout or equal.

Steel

1. Surfaces shall be thoroughly inspected, and when necessary, ultrasonically tested to detect thin spots in the structure which need reinforcement. A fiberglass fabric patch shall be applied whenever corrosion or erosion has removed the safety factor of the steel (generally > 50% of original thickness). A structural repair should be performed when the minimum design thickness of the steel has been breached. Mark the areas to be repaired with compatible zinc primer or epoxy paint. Wherever a thin spot or hole is detected, a repair patch with a minimum radius of one foot outside the edge of the thin area shall be applied per steel repair instructions. An exterior patch is necessary wherever a full penetration has occurred. An area with a minimum radius of six inches should be ground or sandblasted around the hole and a fibermesh repair patch applied to the prepared area per steel repair instructions.

Steel Repair: Fiberglass fabric may be rolled into the resin or chopped glass spray applied with the resin for added tensile and flexural strengths. Fiberglass fabric - A prime or tack coat of **Raven Epoxies** shall be applied to the targeted areas until a 40-80 mil thickness (depending on surface type and specifications) is achieved on all surfaces including voids and holes. Sufficient primer should be applied to completely bond the fibermat to the substrate with minimum fraying and to substantially wet out the fibers. Prior to gelation of the prime coat, sheets of 9 oz/yd^2 (or heavier, according to engineer calculations and specifications) fiberglass fabric should be rolled into the prime coat until fully wetted and embedded including all edges and loose fibers. After the epoxy with figerglass embedded has gelled and is solid to touch (but not longer than the maximum recoat window of the product) loose fibers should be trimmed or ground smooth. Depending on surface type and specifications, an additional 30-65 mils thickness of **Raven Epoxies** should then be applied to the surface of the fibermat. If necessary, additional coats and fiberglass layers may be applied to achieve greater thicknesses, fill remaining voids, cover exposed fibers or achieve additional strength.

Section 3: COATING APPLICATION

Handling

Raven Epoxies are two component 100% solids epoxy systems, which combine fixed ratios of resin to hardener to provide a quality, finished product. The handling characteristics and curing time of any thermosetting system is greatly affected by its temperature and the temperature of the surface to which it is being applied. The higher the temperature of the components or of the substrate or environment, the faster curing will take place. To ensure that the product handles in the way in which it was designed and that you have sufficient pot or working life, it is recommended to store the materials at room temperatures (preferably 70-80 deg F) for at least

24 hours prior to application and review the product data sheet for specific product characteristics. Since it is much more difficult to control the surface temperature of the substrate, common sense should be used to dictate the application time. In extremely hot environments it may be more desirable to apply the product at a cooler time of the day when the sun is less direct, or at night. To avoid problems associated with outgassing, care should be taken to avoid application on concrete and masonry structures exposed to direct sunlight during the application and set time (4 hours after). Tenting, shading or night application is generally acceptable means of avoidance.

The amount of pot life and working life is affected by three criteria: temperature, thickness or mass of the coating and the presence of an aggregate or heat sink. In general, the following guidelines may be used:

1. The higher the temperatures of either the product components or the application surface the faster the cure and set time of the product. To retard the chemical reaction of this two-component system, you may either reduce the temperatures of the components or reduce the temperature of the substrate. The reverse is also true. The ideal temperature of the components during spray application is 125-225 deg F, depending on the product and component. If hand applying, the components can be heated to 125 deg F.

2. Unlike evaporative paints where the thinner the paint the faster it dries, the cure time with thermosetting materials is inversely proportional to the thickness. The thicker the coating and greater the mass, the more heat that is generated producing a shorter set time.

3. The presence of a heat sink can also reduce curing time. A heat sink is anything that can absorb the heat of the reaction, such as a cool substrate, and therefore slow the cure time. The addition of an aggregate to the epoxy mixture can also absorb heat and reduce the reaction time. The addition of more or larger aggregate particles will increase the cure time even further.

Mixing

The following procedures are to be followed when mixing the resin and hardener prior to application:

Hand Mixing/Filled Systems: Mix the resin (Part A) portion thoroughly for 2-3 minutes using an electric or air drill mixer prior to addition of the hardener (Part B). Care should be taken to follow manufacturer specifications for mixing ratios depending on the specific product being used. Add the hardener and continue to mix thoroughly an additional 2-3 minutes. The system is now ready for application. If desired, up to three parts by volume of dry silica sand (or other approved dry aggregate) to one part epoxy may be added to extend the product and create a textured surface or trowelable mortar. Your own tests should be done first to determine which aggregate provides an optimum blended mixture (no dry clumps) and the surface texture desired. Generally, #4 blasting sand will provide a relatively smooth surface, while #3 sand will provide a good skid-resistant texture.

Spray Application: The Raven Application System is a plural component airless spray application system designed and certified for use in applying **Raven Epoxies**. The system pre-heats the product, mechanically ratios the resin and hardener, pumps into and through plural component heated hoses to a mixing block and tubes, then delivers the homogeneously blended end-product to a whip hose and airless, or air-assisted, spray gun.

Application

Once the two components are mixed, a chemical reaction is initiated and heat begins to be generated. **Raven Epoxies** are very reactive and fast setting and it is important that application is begun immediately. By removing the product from the mixing container (when hand mixing vs. spray application) you will lengthen your working time (i.e. dispersing the product mass). If you are manually applying **Raven Epoxies**, it is common to immediately dump the mixed epoxy on to the horizontal surface to be applied and squeegee or roll into place. If a spray system is being used, begin spray application immediately. For quality assurance, it is recommended that at least two coats be applied.

Ideally, Raven Epoxies are to be spray applied by trained and Certified Applicators. Typical minimum and nominal thickness recommendations differ from product to product, depending on the service environment and profile of the prepared surface.

Concrete, New/Smooth:	80-100 mils for immersion, 60-80 mils for atmospheric, splash and spill exposure.
Concrete, Rough:	100-125+ mils
Masonry/Brick:	125-150+ mils
Steel:	25-80 mils for immersion, 16-40 mils for atmospheric, splash and spill exposure; also profile dependent.
Fiberglass System:	40-60 mil tack coat, 9 oz/yd^2 fabric, 40-60 mil top coat. Varies with circumstances.

(Thicknesses shown above are for general purposes only, each project should be evaluated independently and thickness of system determined upon product, service environment, protection and restoration requirements.)

Refer to typical specifications for steel, concrete, masonry or underground structures for more detailed procedures or call Raven Lining Systems for recommendations.

INSPECTION AND TESTING

Thickness - During application a wet film thickness gauge should be used to ensure a monolithic coating and uniform thickness during application.

Touch-Up - After the coating has set hard to touch it should be visually inspected. Touch-up can be made by lightly abrading the surface with grit paper, cleaning the surface to remove debris, dust or other contaminants, and brushing over the area with a mixture of the same material used for the coating per manufacturer's instructions.

Final Inspection: The inspector shall visually check the applied coating for evidence of pinholes, blisters and confirm even coloring, proper mix ratio, coverage and cure. Deficiencies in the finished coating shall be marked and repaired in strict accordance with the manufacturer's recommendations.

Thickness: After the coating has set hard to touch (time will be dependent on conditions), it can be tested with an ultrasonic thickness gauge or destructive testing to confirm specified thicknesses.

Holiday Detection: After the coating has set hard to touch, it can be inspected with high-voltage holiday detection equipment. An induced holiday should be made onto the coated concrete surface and serve to determine the minimum/maximum voltage to be used to test the coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of minimum specified (not average) film thickness applied but may be increased if it is insufficient to detect the induced holiday. All detected holidays should be marked and repaired per the manufacturer's recommendations.

Bond Strength: After the coating has set hard to touch it, can be tested to measure bond strength of the coating system to the substrate. ASTM D4541 can be successfully modified for most field situations. Measurement of bond strength should be made at regular intervals and along different sections of the coated surfaces. The Project Engineer should evaluate any areas detected to have inadequate bond strength. Further bond tests may be performed in that area to determine the extent of potentially deficient bonded area and repairs should be made per manufacturer's recommendations.

Manhole Testing - Type A: Manholes lined in their entirety may be vacuum tested. All pipes entering the manhole should be plugged, taking care to securely place the plug from being drawn into the manhole. The test head shall be placed and the seal inflated in accordance with the manufacturer's recommendations. A vacuum pump of ten (10) inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to nine (9) inches. Following are minimum allowable test times for manhole acceptance at the specified vacuum drop:

DEPTH (FEET)	TIME (SECONDS)		
(Manhole length)	48" diameter	60" diameter	72" diameter
4	10	13	16
8	20	26	33
12	30	39	49
16	40	52	67
20	50	65	81
24	59	78	97
Add these times for 2ft. more depth:	5	6.66	8

Note: These numbers have been taken from ASTM C 1244-93. (reapproved 2000)

If the manhole fails the initial test, repairs and adjustments necessary due to extenuating circumstances (i.e. pipe joint, liner, plug sealing) should be made. Retesting shall proceed until a satisfactory test is obtained.

Manhole Testing - Type B: Manholes lined in their entirety (including invert) may be exfiltration tested. Incoming and outgoing sewer and service lines shall be plugged, the plugs restrained and the manhole filled with water to the top of the manhole frame. A soaking period of up to 1 hour will be allowed if bypassing of the sewage is not required or has been provided for. At the end of this optional soaking period, the manhole shall be refilled with water and the test begun. If the water loss exceeds that shown in the following table, the manhole will have failed the test. Repairs and adjustments necessary due to extenuating circumstances (i.e. pipe joint, liner, plug sealing) should be made. Retesting shall proceed until a satisfactory test is obtained. Maximum Allowable Loss is determined assuming a standard 4 foot diameter manhole.

Depth of Manhole	Maximum Allowable Loss
under 8 feet deep	1 inch in 5 minutes
over 8 feet deep	1/8" per foot of depth in 5 minutes

Return to Service:

The system may be put back into non-severe corrosive service as soon as the coating is set hard to touch (approximately 2-6 hours when applied 60 mils at 70 deg F). For severe corrosion duty such as high concentrate acids, caustics or solvents, 3 to 7 days and/or force cure by heat induction to the coated surfaces may be necessary before returning to service. Manufacturer's recommendations should be strictly followed.

APPLICATOR AND WARRANTY

The applicator will have a minimum of 1-year experience with the application of 100% solids high build epoxy coatings or be trained and certified for application by the manufacturer.

The operators working for the applicator will have a minimum of 1-year field experience working with 100% solids high build epoxy coatings or be trained and approved for operation by the manufacturer.

The applicator shall provide a minimum 1-year warranty for material and labor for failure of the coating and its installation.