In any coating or lining work, obtaining the specified minimum film thickness or the minimum average film thickness is essential. In addition, the applied coating or lining must be uniform and void free to prevent premature failures related to uniformity and coverage that otherwise can and will occur. Specifications call for a required minimum film build, not to verify material use, but because the requirement relates to the overall performance of the project. Knowing the applied film thickness of the coating or lining system as the job proceeds also helps determine if one has obtained sufficient material to successfully complete the application work as specified.

Film thickness can also affect the color, gloss, surface finish, adhesion, flexibility, impact resistance, and hardness of a coating. The effects of film thickness are especially critical for fast-set, plural-component polyurea spray coating and lining systems; however, wet film thickness measurements used in traditional coating and lining work may not readily apply to the polyurea technology due to its unique characteristics.

Failures due to low film thickness could be avoided with proper application training and attention paid to the specification requirements and minimal notched gauges on the applied wet film (wet film thickness gauge). Although this method is fast and economical, the applied coating systems must remain in a liquid state for a period of time to properly use the gauge. With fast-set systems, like polyurea, a wet film gage is woefully inadequate.

Because the polyurea spray elastomer gels or sets very rapidly, usually within 15 seconds, there is no time to place the gauge in the “wet” material, remove the gauge, and achieve an accurate reading. Also, the gauge can become stuck or glued into the polymer system, or it can otherwise damage the material, leaving visible defects (Fig. 1). Dry film thickness (dft) measurements can also be taken to monitor application. The most common method is measuring film thickness on metallic substrates using magnetic thickness gauges. Because the major use of polyurea is for protecting concrete or cementitious substrates, magnetic gauges are not directly suitable. However, contractors can use magnetic gauges with some creativity. By either driving large head metal nails in the concrete substrate, or by placing small metal panels on the surface, followed by application of the coating system, contractors can measure coating dft using magnetic thickness gauges.
Figure 2 is a simple illustration of that procedure.

While the procedure in Fig. 2 may seem simple and ideal, it has some problems. For example, the human factor comes into play. If the coating applicator knows the purpose of the nails or metal panels, he or she may tend to pay more attention during application to areas designated for dft measurement. This tendency may lead to the designated areas being within the average minimum thickness requirements while leaving other areas thinner than required.

The use of the nails or panels can also result in raised or higher levels of the applied coating. Aesthetic issues and performance concerns can result if traffic or mechanical movement is present in a raised area. For instance, if metal panels are not permanently bonded to the substrate, large areas of de-bonding could occur, especially if multiple locations are used for overall thickness measurements, such as in SSPC-PA 2 or SSPC-PA 9,7 So the use of magnetic gauges on coatings over nails or metal on concrete is not always a good approach.

Although destructive, other methods suitable for concrete substrates can include the P.I.G. or Tooke gauge for dft.8 While these methods are typically used on thinner film coating systems (< 10 mils or 254 µm), they can be used on the thicker film coating systems. However, it has been shown in some cases that when using this technique on the thicker applied polyurea elastomeric systems, the resilient qualities of the film build do not allow for a clean cut, and inconsistent readings can occur. Moreover, some may actually not be cuttable because they are soft, and reading of the cut angle is useless for evaluation. Another disadvantage to using destructive measurements is that the test area must be repaired.

Relatively new to the arsenal of the coatings applicator and inspector is the ultrasonic gauges for use on concrete and cementitious substrates.9 These gauges work by sending a signal (ultrasound) pulse through the applied coating system and measuring the time required for the signal to bounce back from the substrate. Using data gathered through ultrasound, the gauge then calculates the coating thickness.

Some writers have discussed why ultrasonic gauges do not work well for applied fast-set polyurea spray elastomer systems.10 One limitation, as is claimed, results from the microcellular makeup of the applied polyurea. The high-pressure impingement mixing needed to apply the coating can cause the coating’s microcellular characteristic, which interferes with the ultrasound signal. The coating also may be deformable under the load of the test probe.

While some of the objections to using ultrasound techniques might be true to a minor degree, some other characteristics of polymers in polyurea systems can help overcome the objections. For example, one characteristic of polyurea spray technology, aside from the possible microcellular nature, is that its polymerisation produces higher molecular weights at the outer surfaces of the cross section of the polymer film11,12 compared to outer surfaces of polyurethanes and epoxy systems that possess relative uniform polymer molecular weight distribution throughout a cross section of the polymer film. Because ultrasonic units work by changes in density, the unit “sees” the applied layers (or spray passes), often causing confusion on thickness evaluations of applied polyurea spray systems.

Fig. 2: Polyurea applied over nail or metal plate
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To avoid confusion, it is very important to calibrate the ultrasound instrument and to verify its calibration before using the unit on the project. Calibration must be reaffirmed throughout the measurement process. Initial spot measurements should be made to give one an idea of the applied coating thickness range. Once the range is confirmed, the gain can be adjusted on the unit to evaluate the thickness range, thus overcoming confusion relating to changes in density. Furthermore, one can get an idea of how many passes or layers have been applied. ASTM D6132, Section 3.3.3, notes that non-uniform coating density can influence accuracy.

The proper transducer probe use is essential for polyurea systems. It has been found that the "D" probe is the optimum and suggested probe to use when evaluating applied film thickness for fast-set polyurea spray elastomer systems.

Concrete Coating and Lining Measurement Testing

As mentioned, one of the largest uses for the polyurea spray elastomer technology is in the coating or lining of concrete substrates. With that in mind, it is very important that proper applied film thickness be observed to insure performance in these application areas. To illustrate the usefulness of the ultrasonic gauges, a series of experimental test panels was prepared.

A series of concrete blocks, 8 in. x 16 in. (20 cm x 40.6 cm) was prepared with a profile of CSP 2 to CSP 3. The top half of each block was primed with an epoxy primer system. In the center of each block, a metal coupon 3 in. x 5 in. (7.6 cm x 12.7 cm) was used for thickness measurement using magnetic gauges. The top portion of the coupon was taped off to allow for conventional micrometer testing of applied dft (Fig. 3). The metal coupons had a surface profile of 3 to 4 mils (76 to 101 µm), as illustrated in Fig. 3.

The four blocks were coated with one coat, two coats, three coats, and four coats respectively, of a fast-set spray polyurea elastomer system, with a gel time of about 10 seconds and tack free time of about 30 seconds. The polyurea system was applied with a plural component, high-temperature/high-pressure proportioning unit, fitted with a mechanical purge impingement mix spray gun. After one hour of application of the polyurea system, each sample was evaluated for system uniformity and applied film thickness.

A visual observation of the coated concrete panels revealed that the one-coat application gave poor, incomplete coverage over the unprimed and primed concrete area, while the two-coat application showed incomplete coverage over only the unprimed concrete area. For each of the four metal samples, complete coverage was noted for the one- to four-coat applications (Fig. 4).

Results

Micrometers, Type 2 magnetic gauges, and an ultrasonic gauge, were used to measure the applied dft of the polyurea spray elastomer system. Table 1 shows the results.

Very good consistency in the measured dft was obtained from the different test methods, including the ultrasonic gauge. However, the results are not exact between methods used. Discrepancies can be explained by the characteristics of the applied polyurea system and the surface profile of the

Table 1: Applied Dry Film Thickness Results*

<table>
<thead>
<tr>
<th>Sample</th>
<th>Micrometer</th>
<th>Type 2, #1</th>
<th>Type 2, #2</th>
<th>Ultrasonic, Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tape area</td>
<td>Metal</td>
<td>Tape area</td>
<td>Metal</td>
</tr>
<tr>
<td>#1, 1 coat</td>
<td>13</td>
<td>10</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>#2, 2 coats</td>
<td>20</td>
<td>18</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>#3, 3 coats</td>
<td>34</td>
<td>29</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>#4, 4 coats</td>
<td>55</td>
<td>43</td>
<td>47</td>
<td>44</td>
</tr>
</tbody>
</table>

*values reported are in mils (thousands of an inch)
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substrate.

Fast-set polyurea systems are not paint materials. Applied polyureas have surfaces that are level but with an orange-peel finish, and the orange peel can cause some measurement issues.\textsuperscript{15} Depending on where one places the gauge probe, varying thicknesses can be measured, and averaging will “smooth out” the results, though the numbers will not be exact. (See ASTM D6132, Section 3.3.2.)

Compared to metals, concrete substrates have a higher profile and porosity, which can account for large spreads in dft evaluations. Use of a primer system is mainly for improved adhesion and other minor issues, but can also prevent penetration of the coating system into the substrate.

**Application and Field Use of Ultrasonic Techniques**

The successful field use of ultrasonic thickness measurements for an applied polyurea system to concrete was confirmed in the following examples.

The concrete floor of a decommissioned facility, once used for manufacture and repair of large electrical transformers but then scheduled for demolition, was contaminated with polychlorinated biphenyls (PCBs), a known health hazard. To protect the demolition crew and minimize the transfer of contaminants, a polyurea spray technology was specified as a floor/capping system. The specification called for a minimum average coating thickness of 60 mils (1.5 mm) in light areas and a minimum average of 120 mils (3.0 mm) in heavy construction equipment areas on the 28,000 ft\(^2\) (2,600 m\(^2\)) facility.

To confirm that the specified film thickness was achieved, an ultrasonic gauge was used to verify the coating thickness and measurements were taken, using the SSPC-PA 2 procedure for frequency characterization (because SSPC-PA 9 had not yet been published). Measurements taken throughout the project were found to meet the minimum specified film thickness in the noted areas. However, the specifier expressed some doubt about the validity of the results, so to confirm the readings, micrometer measurements of the thickness of removed blisters were taken. The micrometer measurements correlated with the results of the ultrasonic gauge.\textsuperscript{16}

Polyurea was specified as the lining for a concrete secondary containment area in the diesel, jet fuel, and MOGAS storage area of a major Air Force facility. The specification called for a minimum average thickness of 80 mils (2.0 mm), applied over a failing epoxy lining system. Ultrasonic thickness testing was again used to monitor the applied film build. To confirm the thickness measurement of the ultrasonic gauge, caliper measurements were taken from samples obtained from destructive pull-off adhesion testing, as was specified for certain areas of the project.\textsuperscript{17} In this work, the adhesion testing afforded the ability to confirm the applied film thickness noted with the ultrasonic gauge by use of micrometers. Of course, these test areas required repair of the lining system before the customer would accept the project.

**Conclusion**

In order to insure performance of an installed coating or lining system, monitoring of applied film thickness is crucial to success. Many physical and appearance properties of the finished coating or lining are affected by applied film thickness. These include color, gloss, surface finish, adhesion, flexibility, impact resistance, hardness, and “fit” of coated pieces. The coating and lining applicator and inspector have a variety of tools to monitor applied coating thickness. While tools are readily available and easy to use for film thickness measurements on metallic substrates, measurement on concrete or other cementitious substrates is more difficult. However, work described in the article has shown that ultrasonic gauges and the related industry test procedures are in fact effective measuring tools, even for the fast-set polyurea spray elastomer technology.

**References**

2. Polyurea Applicator Spray Course, Polyurea Development Association, Kansas City, MO.

Continued
PREQUALIFICATION OF PROSPECTIVE BIDDERS: The New Jersey Turnpike Authority is seeking Contractors to become prequalified under Classification 9, Painting and Classification Rating H, Unlimited, utilizing the Authority’s Prequalification process in anticipation of the referenced contract.

GENERAL DESCRIPTION OF WORK: The Washington Memorial Passaic River Bridge is located on the New Jersey Turnpike Easterly Alignment between Interchange 15E in the City of Newark, Essex County and the Hackensack River Bridge in the Town of Kearny, Hudson County and has an estimated AADT of nearly 130,000 vehicles per day. The bridge measures 6,948 feet long and carries three (3) lanes with a full shoulder in the Northbound and Southbound directions.

The typical bridge cross section consists of four (4) main deck girders with floorbeams and stringers. The five span main river unit consists of a three span continuous unit with suspended approach spans attached with pin and hanger connections. The south suspended span is 190 feet long and has a minimum vertical clearance of 110 feet above ground. The north suspended span is 190 feet long with a minimum vertical clearance of 98 feet above railroad tracks. The main river unit is 985 feet long and crosses railroad tracks with a vertical clearance of 113 feet, and the Passaic River with a vertical clearance of 110 feet above a 270 foot wide shipping channel. The south approach consists of 19 simple spans that range from 76 to 160 feet in length and that cross roadways (3 spans), railroad tracks (3 spans), and Turnpike and private ROW (13 spans). The south approach also passes under the Pulaski Skyway with a 15 foot minimum vertical clearance above the deck. The north approach consists of 24 simple spans that range from 92 feet to 136 feet in length and that cross roadways (2 spans), railroad tracks (1 span), and open areas of NJ Turnpike and private ROW (21 spans). Riveted fabrication of painted carbon and silicon steel is used throughout the original center section of the structure, and bolted fabrication of weathering steel is utilized throughout widenings of the bridge in both directions.

Contract No. T100.116: Work shall include the removal of approximately 185,000 SF of weathering steel within the widened portion of the structure. The work on the weathering steel will specifically involve the beam-ends, areas below bridge deck joints and areas as directed in the field during construction. The existing paint system will be replaced with a New Jersey Turnpike Authority approved three coat system (Zinc Primer / Epoxy Intermediate / Aliphatic Urethane Finish). Work shall also include Maintenance and Protection of Traffic and other incidental work called out in the contract documents. Estimated Construction Cost: $40M-$50M.

PREQUALIFICATION PROCEDURE: A copy of the “Procedure for Prequalification and Award of Construction Contracts” is available at: http://www.state.nj.us/turnpike/Contractor-prequalification.pdf. The package will be furnished upon written request to: New Jersey Turnpike Authority; Engineering Department; P.O. Box 5042; Woodbridge, New Jersey 07095-5042; Attn: Mrs. Jane Pietraska, Bid Supervisor; 732-750-5300, ext. 8253.

Please provide your e-mail address, mailing address, telephone number, contact person and title with your request. The completed “Procedure for Prequalification and Award of Construction Contracts” package and supporting Contractors Qualifying Statement are due by April 9, 2009.

GENERAL INFORMATION:
Evaluation: The evaluation is solely for the purpose of determining, in a timely manner, bidders who are deemed qualified under NJAC 19:9-2.7 for the type and scope of work included in the project. The contract will be awarded to the prequalified bidder submitting the lowest responsive bid.
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Editor’s Note: This article is based on a paper the authors gave at PACE 2009, the joint conference of SSPC: The Society for Protective Coatings and the Painting and Decorating Contractors of America, held February 15-18, 2009, in New Orleans, LA.

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Dudley J. Primeaux II is a consultant and the owner of Primeaux Associates LLC (Elgin, TX), which specializes in the polyurea industry, equipment, application, training, and inspection. He is part of The Polyurea Training Group, which provides various training programs relating to all aspects of polyurea technology, and he is the instructor for the Polyurea Development Association (PDA) Spray Applicator Course. Mr. Primeaux has an M.S. degree in organic chemistry from Lamar University in Beaumont, TX, and was employed by Texaco Chemical Company, Huntsman Corporation, and EnviroChem Technologies, LLC, as a partner before forming Primeaux Associates LLC.

Mr. Primeaux is active in SSPC, NACE, and PDA, where he is a past-president and a member of the Board of Directors. He has also completed the SSPC PCS Protective Coatings Specialist and SSPC CCI Concrete Coatings Inspector certifications. He is an inventor of 26 U.S. patents and 8 European patents on polyurethane and polyurea foam applications, as well as polyurea spray elastomer systems and applications. He has authored over 40 technical papers on polyurea elastomeric coating and lining technology, as well as several chapters in SSPC book publications.

Kelin Bower

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<table>
<thead>
<tr>
<th>Date</th>
<th>Course</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 6-10</td>
<td>Fundamentals of Protective Coatings</td>
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<td>Shenzhen, China</td>
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<td>April 15</td>
<td>Fundamentals of Protective Coatings</td>
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<tr>
<td>April 15</td>
<td>Applicator eCourse</td>
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<td>Norfolk, VA</td>
</tr>
<tr>
<td>April 20-21</td>
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<td>Cincinnati, OH</td>
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<td>April 20-24</td>
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