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16. Abstract This brief summary report documents the main findings from the work done in the last fiscal year. This summary report is composed of three major components: 1) Overlay Tester for crack sealants and associated draft test protocol, 2) repeatability of Overlay Tester for crack sealant, and 3) sensitivity of Overlay Tester for crack sealant. Finally, this report discusses the work recommended by the Pavement Monitoring Committee on October 11, 2006.					
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**PRELIMINARY RESULTS OF REPEATABILITY AND SENSITIVITY
STUDY ON OVERLAY TESTER FOR CRACK SEALANTS**

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There is no invention or discovery conceived or first reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

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- Jerry Peterson, P. E.
- Ted Moore, P. E.
- Richard Williammee, P. E.

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PRELIMINARY RESULTS OF REPEATABILITY AND SENSITIVITY STUDY ON OVERLAY TESTER FOR CRACK SEALANTS

Per discussion with the Project Monitoring Committee (PMC) for Project 0-5457 at the Texas Transportation Institute (TTI) office during the Texas Department of Transportation (TxDOT) short course on October 11, 2006, this report summarizes and presents progress in a very brief format. This brief summary report is composed of four major components: 1) Overlay Tester for crack sealant and associated draft test protocol, 2) repeatability of Overlay Tester for crack sealants, 3) sensitivity of Overlay Tester for crack sealants, and 4) further research recommended by the PMC on October 11, 2006. Detailed information is presented below:

1. Overlay Tester for Crack Sealant and Associated Draft Test Protocol

After being authorized by the PMC in February 2006, TTI ordered a new Overlay Tester for evaluating crack sealant performance. In late June 2006, the manufacturer delivered the Overlay Tester machine shown in [Figure 1](#) to TTI. After fixing several software and hardware problems, the Overlay Tester is working well. At the end of this project, this Overlay Tester machine will be delivered to TxDOT. The new features of this new Overlay Tester machine are as follows:

- 1) test temperature: +95 to +23 °F (+35 to -5 °C),
- 2) maximum opening displacement: 0 to 0.5 inch (0 to 12.5 mm), and
- 3) loading time: 0.1 to 3600 sec.



Figure 1. TTI Overlay Tester for Crack Sealant.

After a series of shake-down tests were conducted, TTI researchers recommended a preliminary Overlay Tester protocol for evaluating crack sealant, which includes sample preparation. The key components of this protocol are listed as follows:

- Sample size (Figure 2)
 - mortar size: 3-inch long by 3-inch wide by 1-inch high, and
 - sealant size: 3-inch long by 0.5-inch wide by 1-inch high.

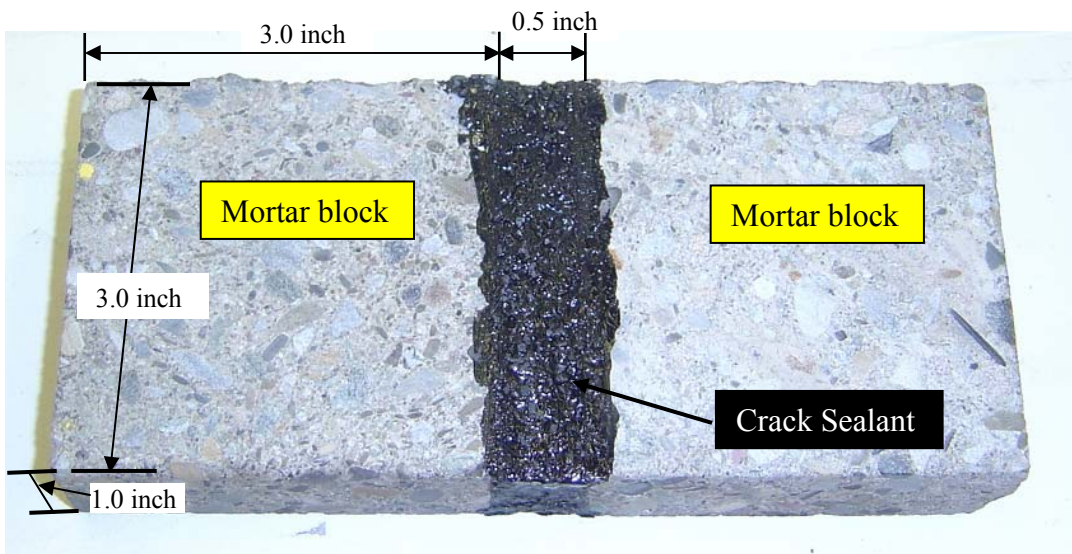


Figure 2. Sealant plus Mortar Blocks.

- Mortar block set-up: clamp+bolt (rapid set-up as shown in [Figure 3](#)).
- Testing temperature: 41 °F (5 °C).
- Open displacement: 0.10 inch (2.5 mm).
- Triangular cyclic loading: 5 sec on and 5 sec off.
- Definition of failure: 80 percent load reduction from the maximum load recorded in the first cycle.
- Sample preparation: after recognizing the non-uniformity of the poured sealant sample initially molded, a sample molding set-up was designed and fabricated, as shown in [Figure 4](#). With this set-up, the sealant samples prepared are much more uniform than previous samples.

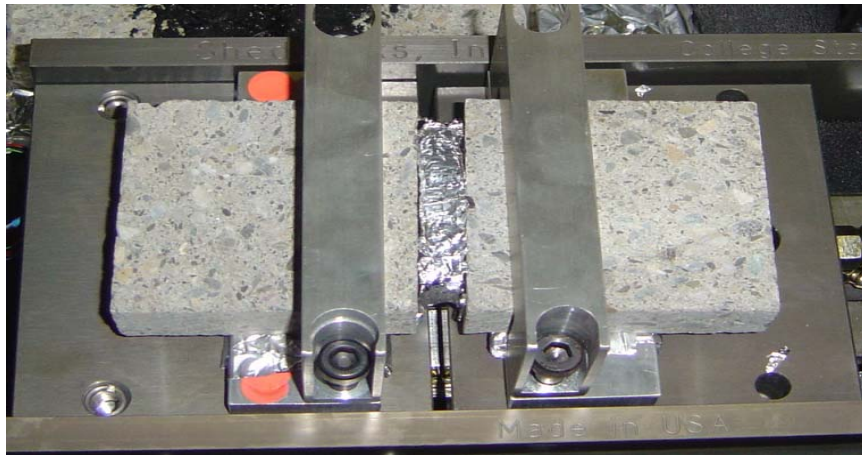


Figure 3. Clamping Set-up.

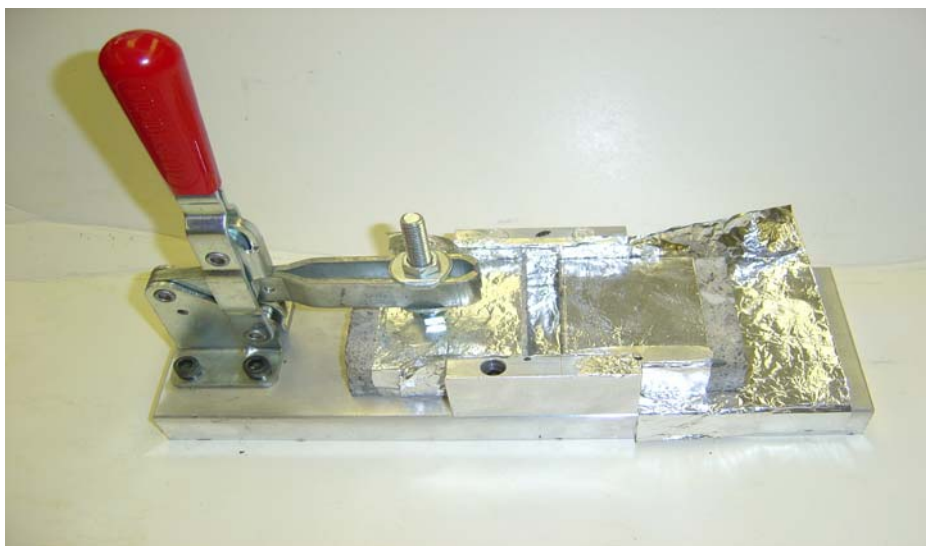


Figure 4. Sealant Preparation Set-up.

2. Repeatability of the Overlay Tester for Crack Sealants

Sealants Selected for Repeatability Study

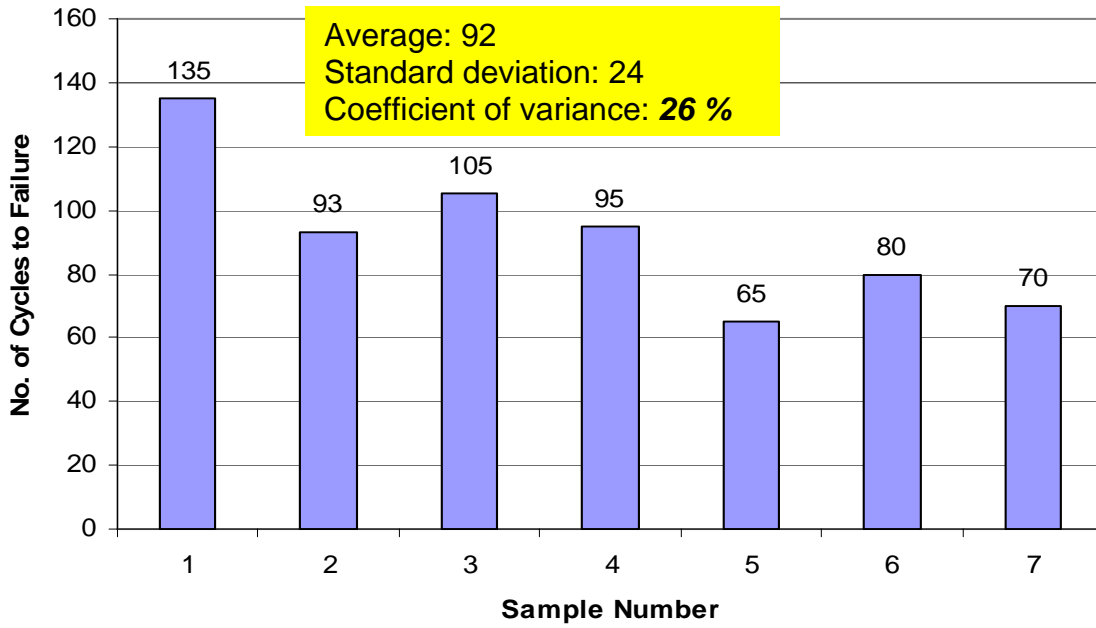
Four hot-pour sealants collected previously from TxDOT Project 0-4061 were used for this repeatability study. These four sealants are H1: Type A crack sealant, H2: Type B crack sealant, H3: Type A crack sealant, and H4: joint sealant. The repeatability studies were conducted two times. In the first repeatability study, all four sealants were investigated. During the PMC meeting on September 13, 2006, the PMC directed the researchers to work on only three crack sealants: H1, H2, and H3. Therefore, only repeatability studies on these three sealants are presented in this report.

Results of Repeatability Study

For each sealant, seven sealant samples were prepared for repeatability investigation. All the tests were conducted with the draft test protocol proposed in [Section 1](#) (41°F and 0.10 inch opening). The results of the two-time repeatability study on the three sealants are presented in [Figures 5, 6, and 7](#). Note that the main differences between the first and the second run are: 1) sealant sampling: the sealant for the first run was sampled by digging from the top surface; for the second run, a core drill was used to sample the sealant from the top to the bottom by drilling through the sealant; and 2) as noted previously, a sealant preparation set-up (shown in [Figure 4](#)) was used in the second run to make the prepared sealant sample more uniform. The statistical analysis results (average value, standard deviation, and coefficient of variance) for each sealant are also presented in each figure.

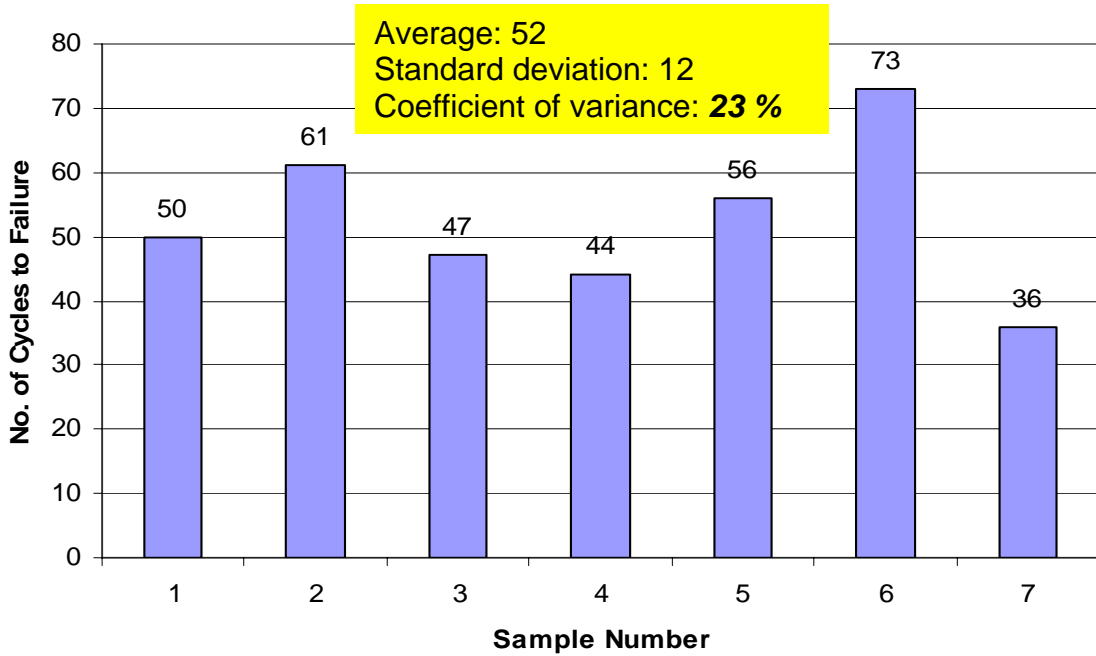
The results from the second runs are more consistent, although there is no significant improvement in the coefficient of variance. In addition, for sealant H2, significant difference was found between the first run and the second run, which may be caused by sealant segregation and core drilling or other factors. More work is underway to confirm this finding.

Sealant H1: Type A



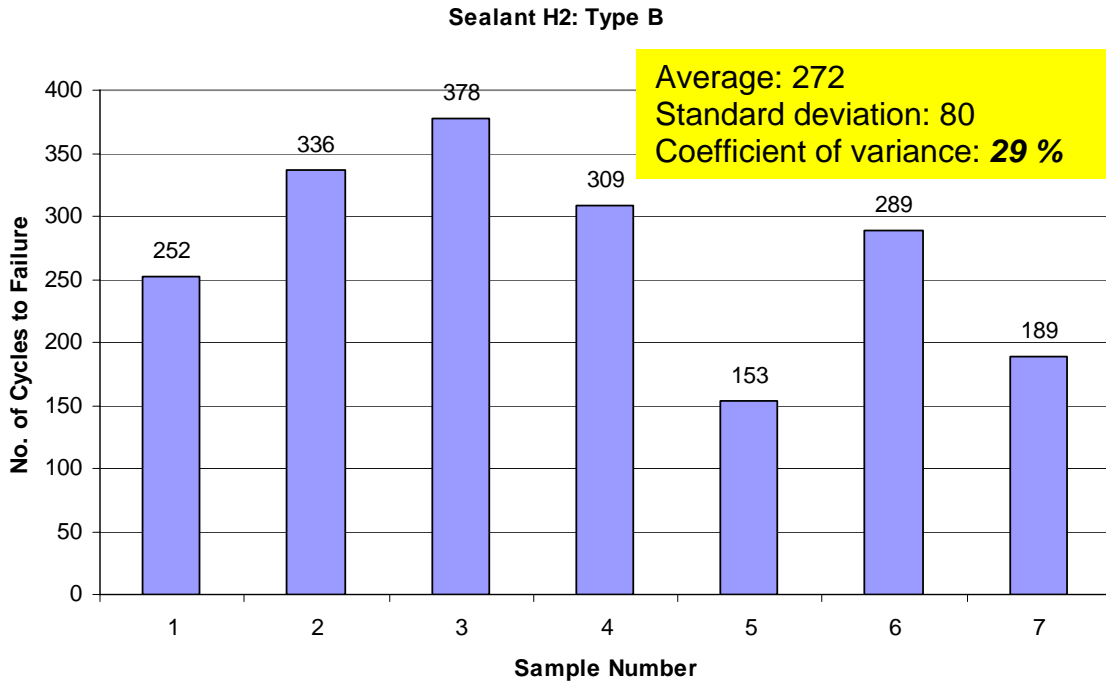
(a) First Run Repeatability Study.

Sealant H1: Type A

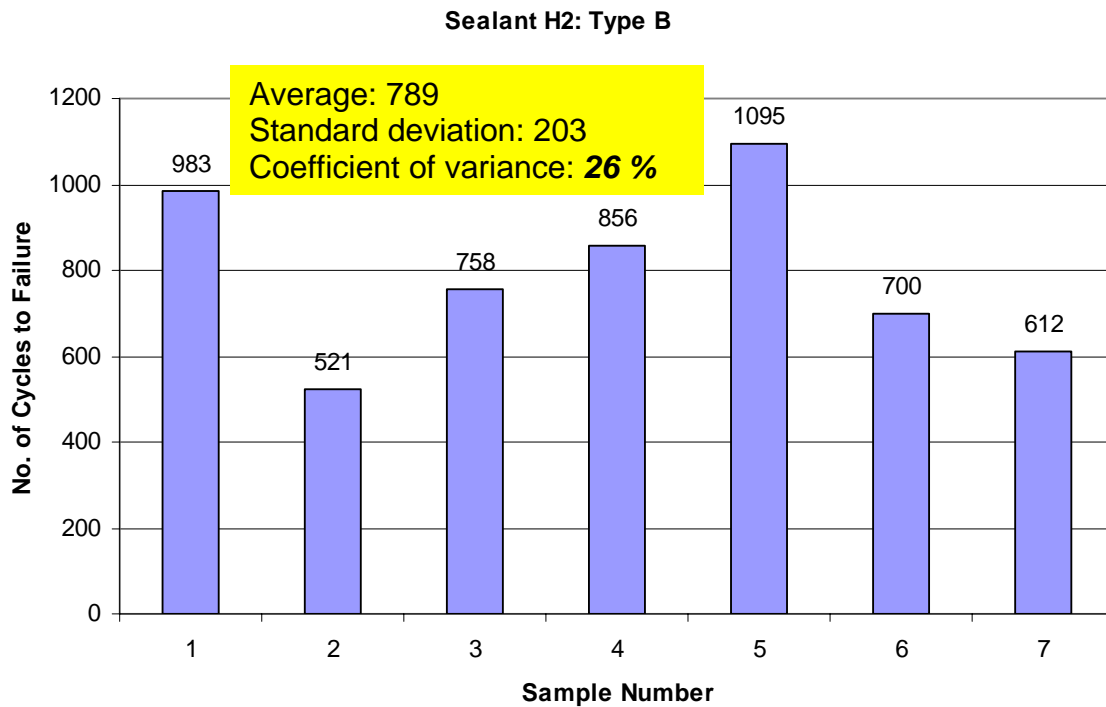


(b) Second Run Repeatability Study.

Figure 5. Repeatability Study on Sealant H1: Type A.

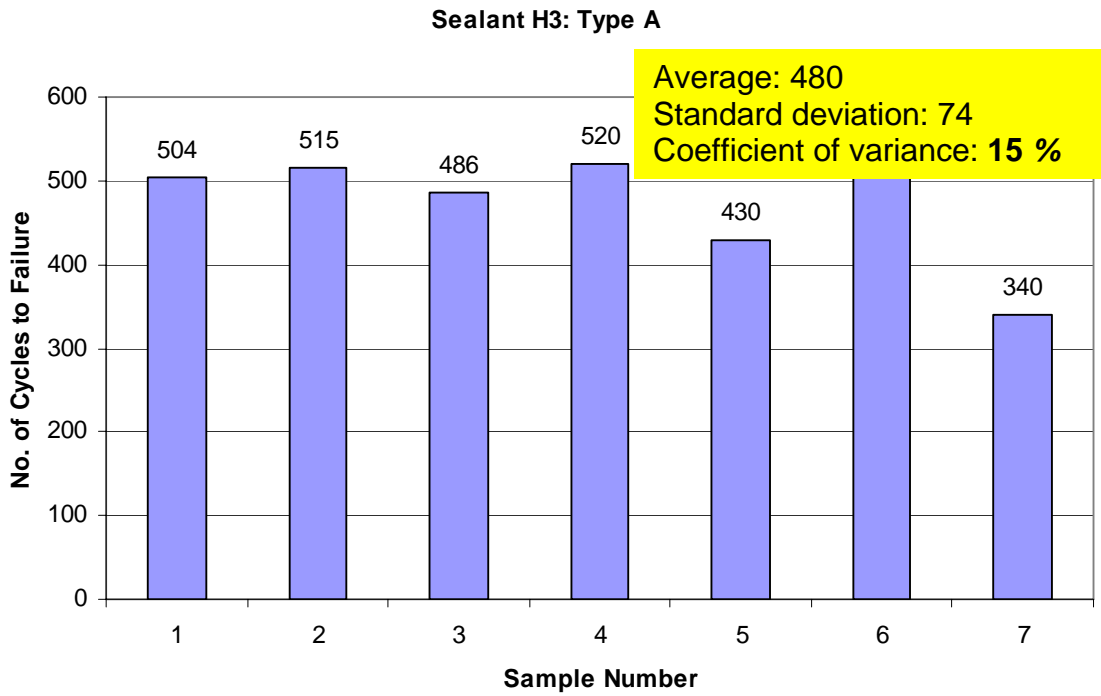


(a) First Run Repeatability Study.

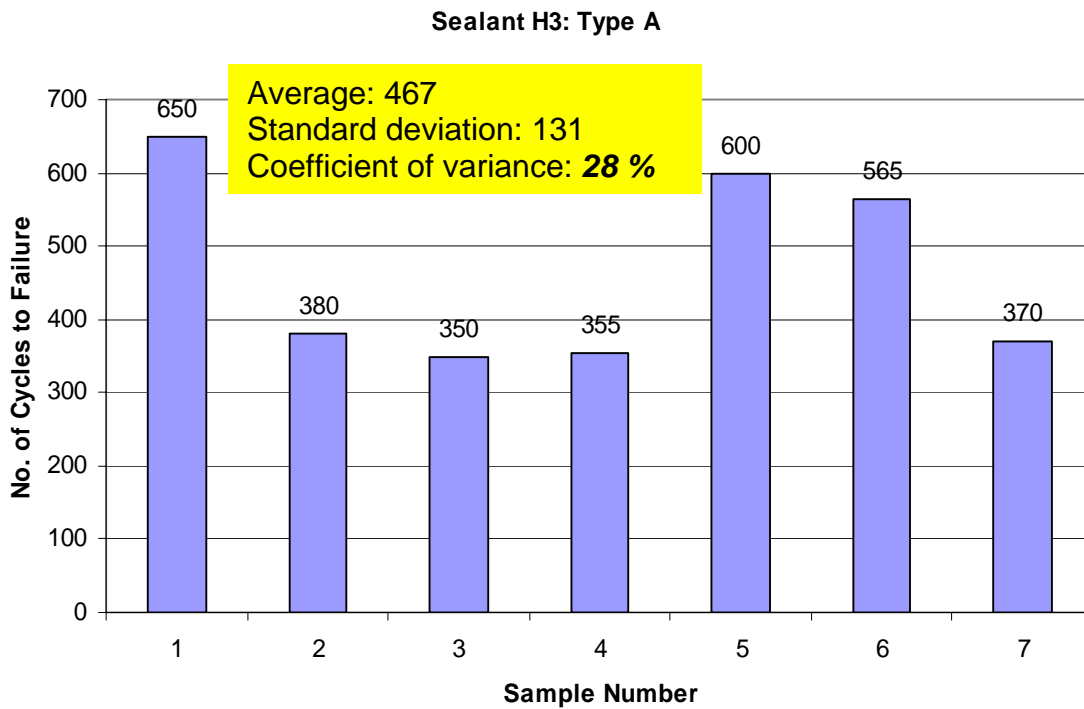


(b) Second Run Repeatability Study.

Figure 6. Repeatability Study on Sealant H2: Type B.



(a) First Run Repeatability Study.



(b) Second Run Repeatability Study.

Figure 7. Repeatability Study on Sealant H3: Type A.

Number of Samples

Another important issue for a repeatability study is to determine the number of samples required to obtain an estimate of the material property within certain tolerances, since variation inevitably occurs from sample to sample even in the same material. This is a classic application of confidence intervals in a statistical analysis. For a known population variance, the number of replicates required to achieve the specified levels of tolerance and reliability is defined in the following well-known [Equation 1](#):

$$n = \left(\frac{Zs}{\Delta x} \right)^2 \quad (1)$$

where:

n = number of specimens,

Z = two-tailed probability statistic from the standard normal distribution,
generally 1.96 is chosen for Z with a 95 percent reliability,

s = population standard deviation,

Δx = specified tolerance value ($= x_{average} * \text{specified tolerance}(\%)$), and

$x_{average}$ = average value of population.

For each sealant, using [Equation 1](#), the number of samples required versus the specified tolerance can be calculated, as shown in [Figure 8](#). In view of [Figure 8](#), five replicates of samples are recommended for evaluating adhesive performance of sealants. The errors will be between 20 to 25 percent from the “true” value.

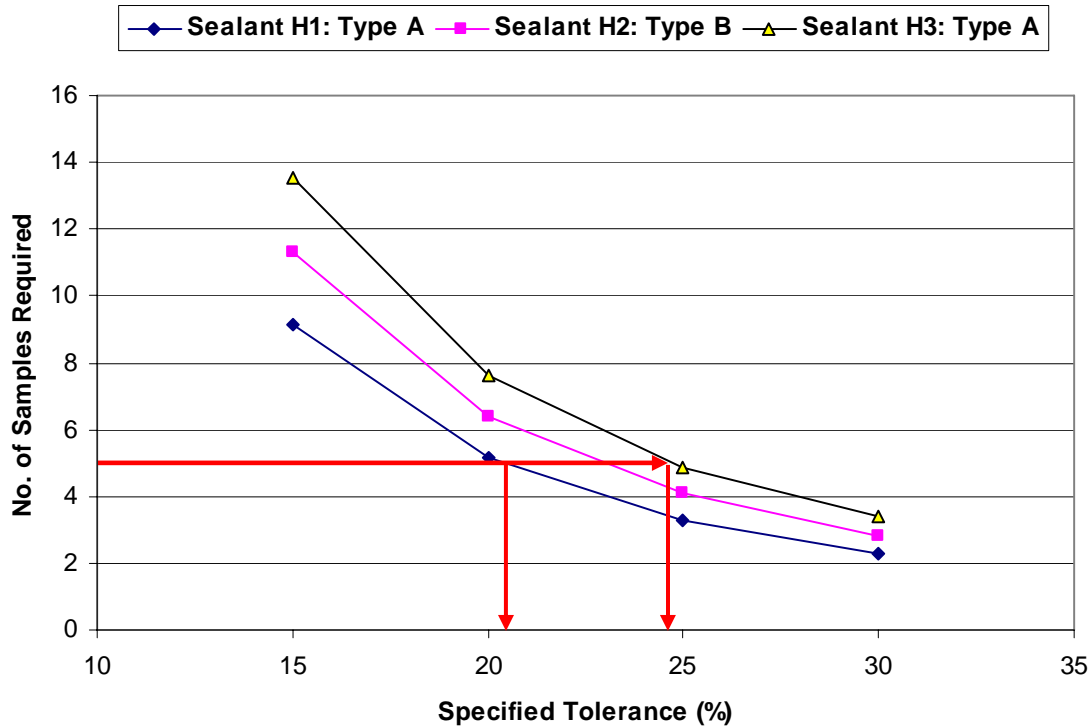


Figure 8. Relationship between the Number of Samples Required and Specified Tolerance Based on Equation 1.

3. Sensitivity of the Overlay Tester for Crack Sealants

It is well known that performance of crack sealant in the field is influenced by many factors such as air temperature and temperature drop. Three critical factors have been identified under this sensitivity study. These three factors are dirty condition of the crack walls, test temperature, and opening displacement (or temperature drop). As expected, early adhesive failure happens if the crack wall is dirty or dusty. Also, with increasing opening displacement (or more temperature drop) crack sealant fails faster in the form of adhesive failure.

One surprising finding from the sensitivity study is temperature sensitivity of crack sealant H1: Type A, as shown in Figure 9. As recommended by David Head, Project Coordinator, at the meeting on September 13, 2006, tests were conducted at three test temperatures: 39, 41, and 43 °F. All test conditions were kept the same except test temperatures. Note that this sealant was already evaluated at test temperature of 41 °F during the above repeatability. Thus, only two other test temperatures (39 °F and 43 °F)

were conducted during the sensitivity study. At temperatures of 39 °F and 43 °F, five replicates of samples were used for this sensitivity study based on the repeatability study. In view of [Figure 9](#), it is clear that this H1 sealant is very temperature sensitive, which indicates that different districts may need totally different types of sealants because of different temperature zones. Clearly, more research is urgently needed in this area. When presented with this phenomenon, the PMC outlined the new research direction presented in the next section.

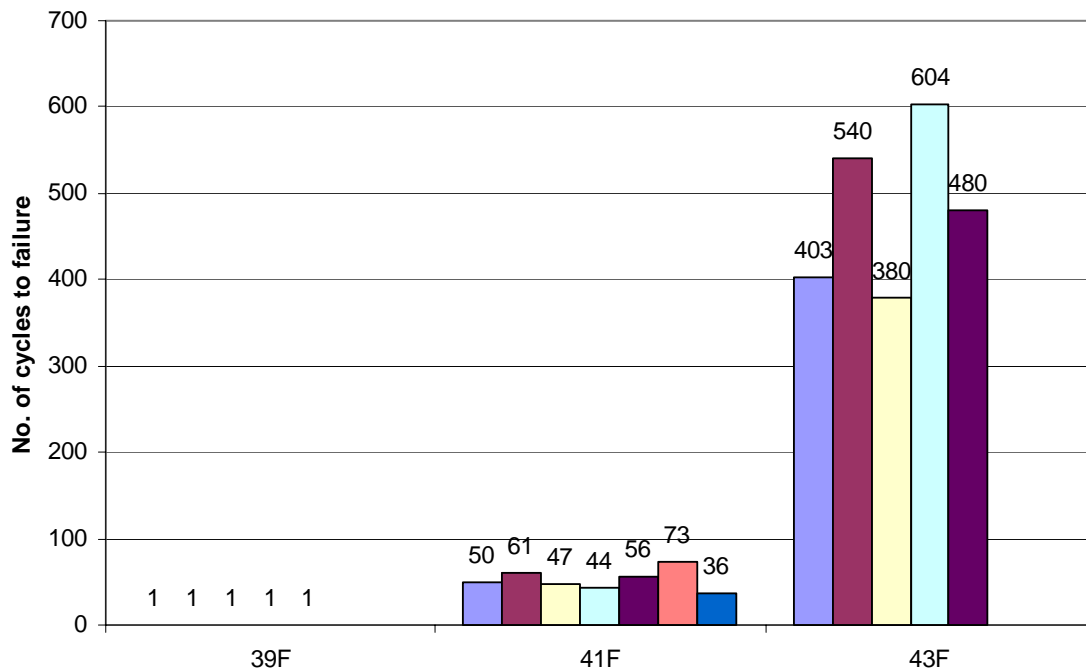


Figure 9. Temperature Sensitivity Study of Crack Sealant H1: Type A.

4. Further Research Recommended by the PMC at Meeting on October 11, 2006

In addition to recognizing the necessity of conducting the temperature sensitivity study on the other two sealants (H2 and H3), the PMC also proposed reinvestigation of the potential use of aluminum blocks (shown in [Figure 10](#)) for sealant testing because these blocks have several advantages: 1) reusable, 2) uniform, 3) easy to clean, and 4) unlikely to break during clamping. In summary, the following items are going to be done before the end of November 2006:

1. conduct the same temperature sensitivity study on the other two sealants:
H2: Type B and H3: Type A sealants;
2. investigate the potential use of aluminum blocks for sealant test; and
3. review new test results and meet with vendors at the end of November 2006 in Austin.

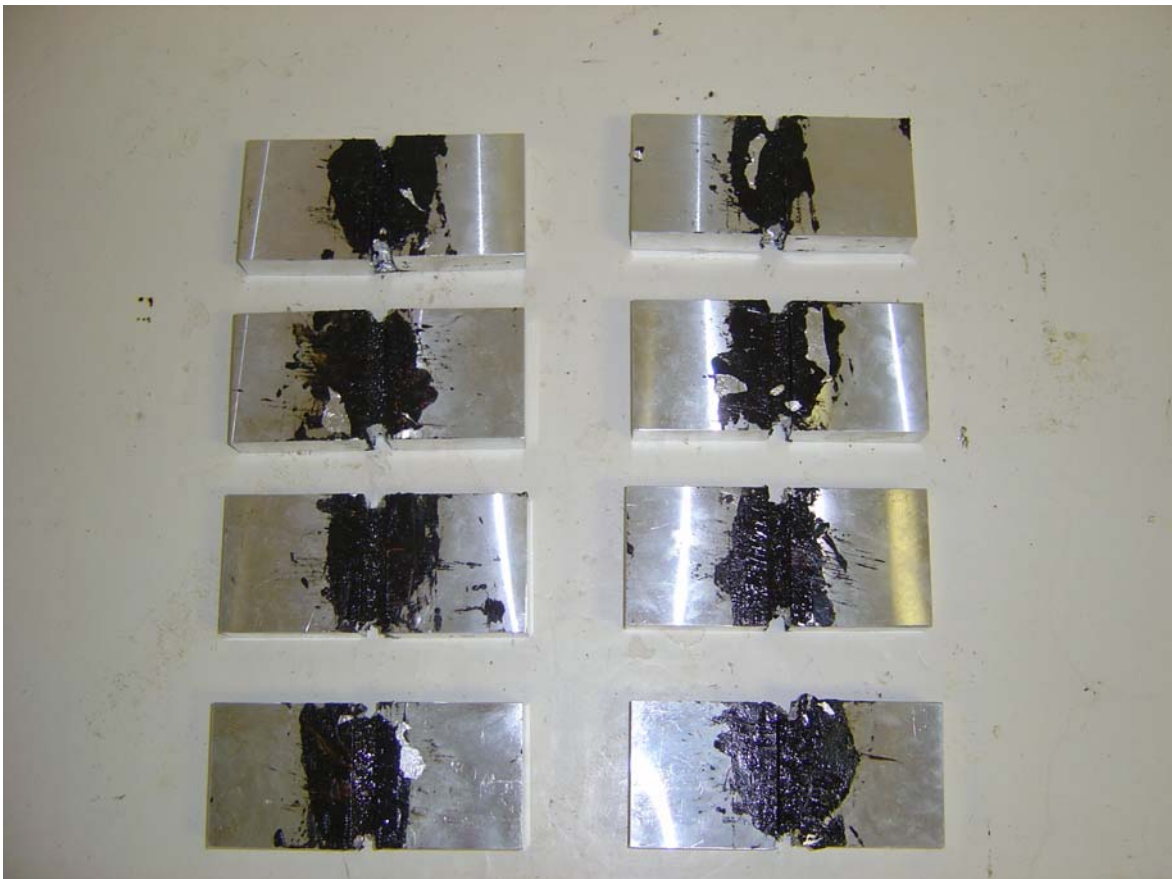


Figure 10. Aluminum Blocks with Sealant.

