Thermal Systems and Materials Testing

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Abstract

During my internship, I was involved in Boeing Thermal System/M&P, which handles maintenance and repairs of shuttle tiles, blankets, gap fillers, etc. One project I took part in was the revision of TPS-227, a repair process to tiles that entailed drilling out tile damage and using a cylindrical insert to fill the hole. The previous specification used minimal adhesive for application and when the adhesive cured, there would be several voids in the adhered material, causing an unsatisfactory bond. The testing compared several new methods and I analyzed the number of voids produced by each method to determine which one was most effective at eliminating void space. We revised the original process to apply a light adhesive coat to the top 25% of the borehole and a heavy coat to 100% of the insert.

I was also responsible for maintaining the subnominal bond database, which records all unsatisfactory SIP (Strain Isolator Pad) bonds. I then archived each SIP physically for future referral data and statistics. In addition, I performed post-flight tile inspections for damages and wrote dispositions to have these tiles repaired. This also included writing a post-flight damage report for a section of Atlantis and creating summarized repair process guidelines for orbiter technicians.

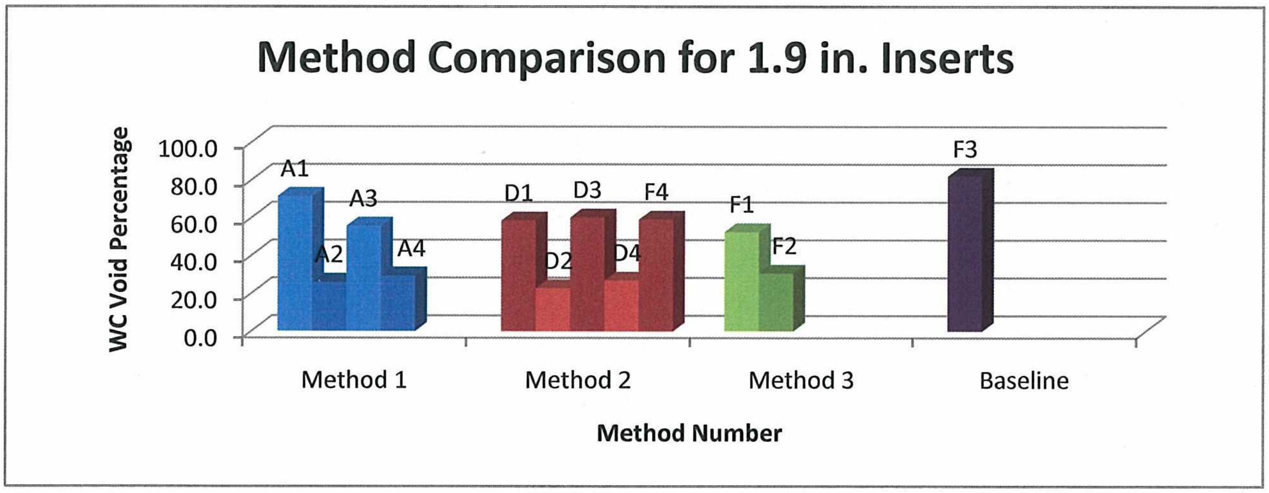
Goals and Purpose

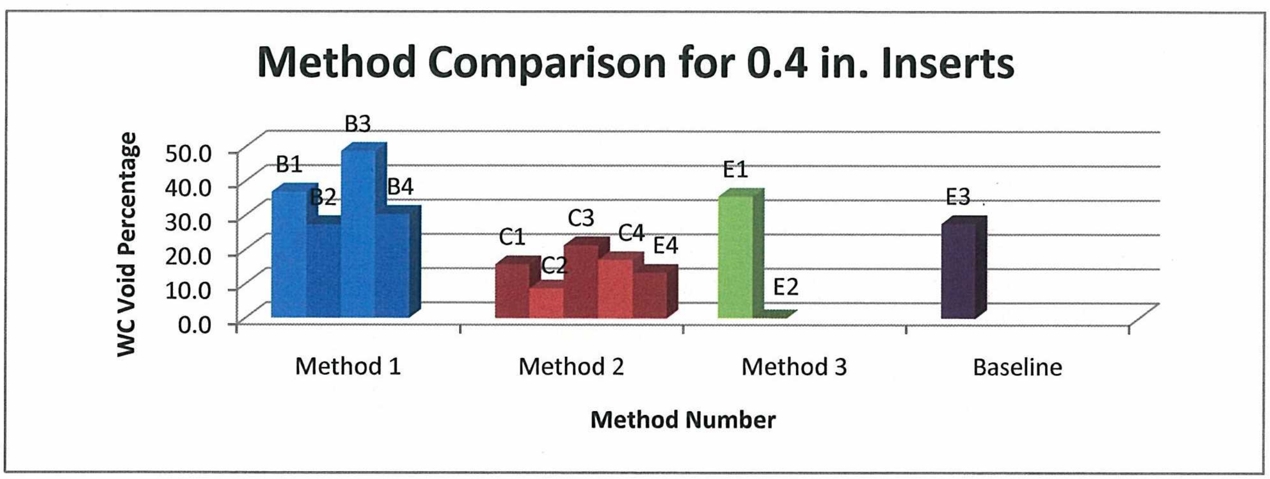
Previous specifications concerning insert usage yielded results that were adequate, but not as effective to ensure the 300% safety factor. This baseline specification entailed thick application to 50% of the insert and no application to the borehole. In this case, testing was done to compare three methods of insert application. The procedures were as follows:

- Method 1: 100% thick application to insert, no application to borehole
- Method 2: 100% thick application to insert, 25% thin application to borehole

- Method 3: 100% thick application to insert, 100% thin application to borehole

Method 3 was hypothesized as not applicable for general use, and was only tested in order to demonstrate worst case application to the insert by operator error. This was important to examine because a significant aspect to this process is to avoid contamination of the strain isolation pad (SIP). These tests were performed using 1.9 in. long inserts and 0.4 in. long inserts. Four trials were performed for Method 1, five for Method 2, and two for Method 3. These were then compared to the baseline by comparing the depths and lengths of the voids, after the coating dried, through cross-sectioning each borehole, and measuring the worst case void depth on each sample. The following graphs illustrate the percentage of space that each worst case void creates:





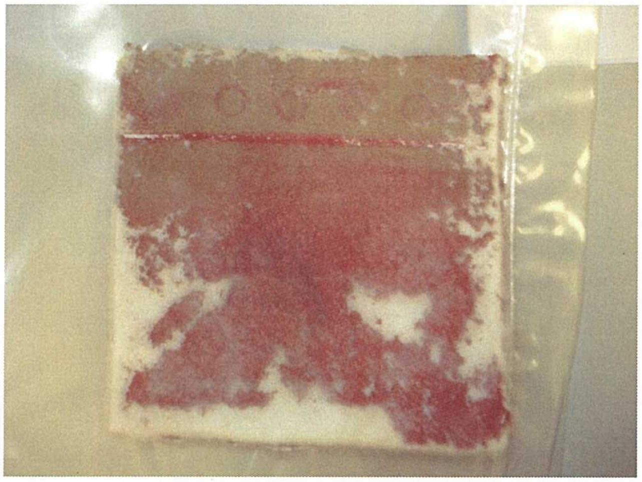
The result of this testing was that there was a definite improvement in using Method 2, while Method 1 yielded little to no improvement and Method 3 did not show enough of an improvement to justify the use of excess adhesive and greater risk for SIP contamination.

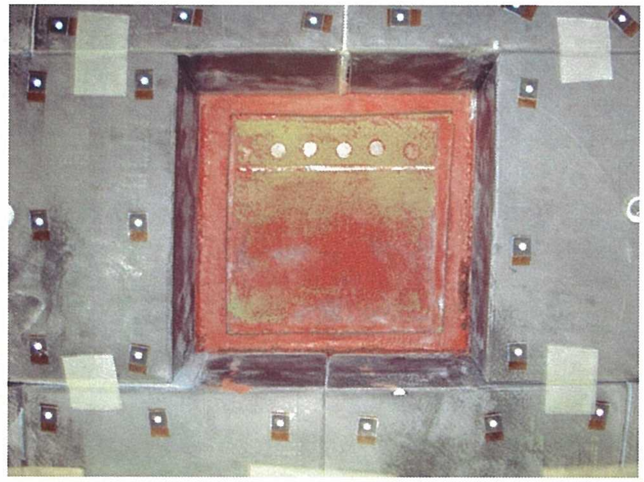
The specification was altered to adhere to Method 2 of the procedure. Further, it was also changed by requiring the usage of plugs to block one end of the borehole while applying the paste in order to protect the SIP.

Another project that came about was the testing of RTV, an agent, when catalyzed, is used for bonding the SIP to the orbiter. Some orbiter technicians mistakenly used almost an entire bucket of RTV that had passed it shelf life. In total, there were 22 mixes made using this RTV, meaning a minimum of 22 tiles were bonded with it, although each mix could be used multiple times, so the true number of tiles bonded as such is likely to be much greater. The approach to the testing was simple: use the remainder of the RTV to bond two pieces of metal together, and if the bond sufficiently withstands a pull test, the previously bonded tiles are adequately bonded to remain attached to the orbiter.

The procedure for this test involved cleaning the metal plates with sand paper to ensure no gaps or residue would disturb the adhesion. They were further treated with a cleansing agent and left to dry for 48 hours. Then, two plates were bonded together by the mixture of RTV and catalyst and left to cure. There were a total of 12 samples and each was more than adequately bonded. This meant that it was not necessary to remove the tiles bonded with this batch of RTV.

My final large project was data input and analysis of subnominal bonds, which are bonds between the Strain Isolator Pad (SIP) and the orbiter or tile. The purpose of the SIP is to reduce stress and during tile removal, when a technician suspects there is a subnominal bond, a Boeing engineer examines the SIP and determines whether or not a subnominal bond exists, and how to go about correcting it. After technicians or the engineer removes the bond, the SIP is saved and eventually archived in a database for trend analysis. Below is an example of a subnominal bond.





The image on the left shows the SIP post-removal while the image at right displays the SIP and tile recess. The red-orange color presence on either image is dried RTV. On the right image, note the red-orange border. This is filler bar. The SIP is bonded inside this border, and the tile bonds to both the SIP and filler bar. In this case, the bond was subnominal because of the evidence of koropon overspray (the green coloration in both images). Koropon essentially acts as a primer, but is not supposed to have been on the bonding surface, as this reduces the adhering capability of the RTV. Further, there was also poor surface preparation on this SIP due to the face that the center of the recess is slightly shiny. This indicates that the RTV applied there did not properly cure, perhaps due to an insufficient amount of catalyst being added. As such, the bond there is a little weaker than it would be otherwise.

Impact

This internship has been an amazing experience. It has helped me gain a much greater understanding of the inner workings of NASA and the shuttle program. It has further given me more experience in engineering and materials analysis. It has made me more aware of opportunities for professional growth and development that I otherwise would remain completely ignorant.

In addition, this experience has offered me real-world application of several topics that previously were merely abstract issues and posed questions that never really held any meaningful concern. The chance to work with textbook ideas by hand has certainly been a very enlightening opportunity. It has solidified my goals to continue my STEM education.

The mentor/intern relationship has most certainly been one of the most valuable aspects of the internship. I realize that without the knowledge and experience of my mentor, I really do not know how I would have been able to make this internship successful and enlightening for me. For example, for the week, I was introduced to so many acronyms for every document and every process and every building, it was mind-boggling. Without my mentor, I would still be confused today, nine weeks later.

The enrichment seminars, in particular the MUST symposium in Cleveland, were some of the most interesting and inspiring meetings and workshops I have ever had the chance to attend. To be able to listen to the stories and the advice of so many successful people was simply amazing. Altogether, I am so very thankful to have been given this chance and I can only look forward to next summer for another opportunity like this.