SAND2014-16347D

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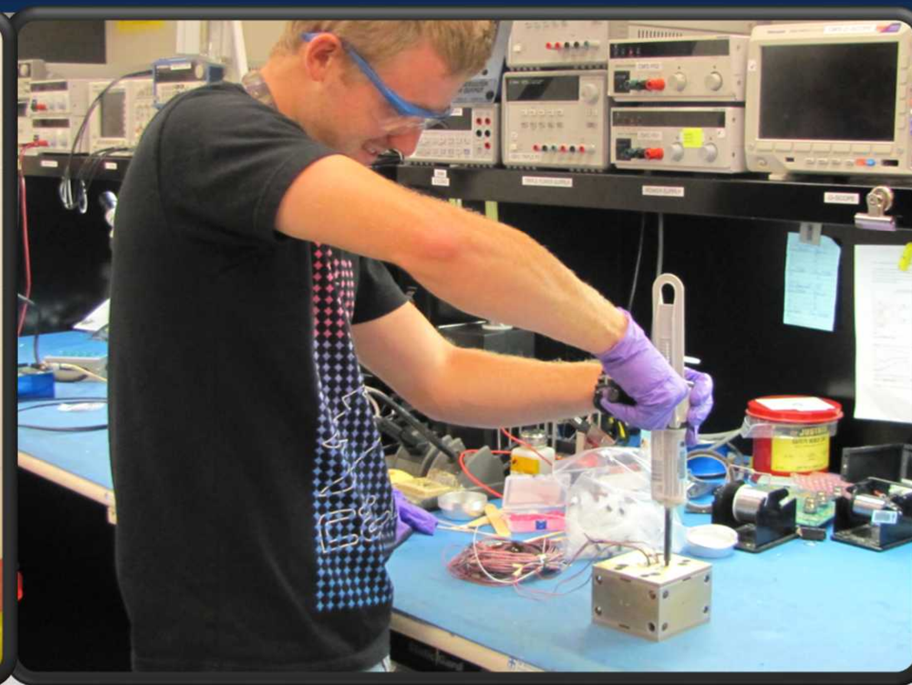
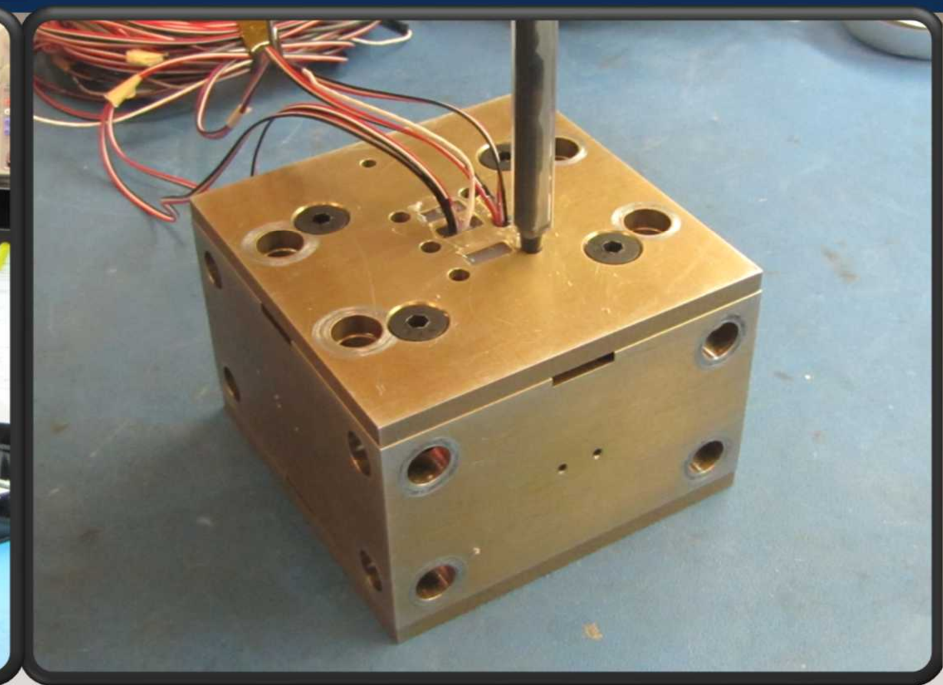
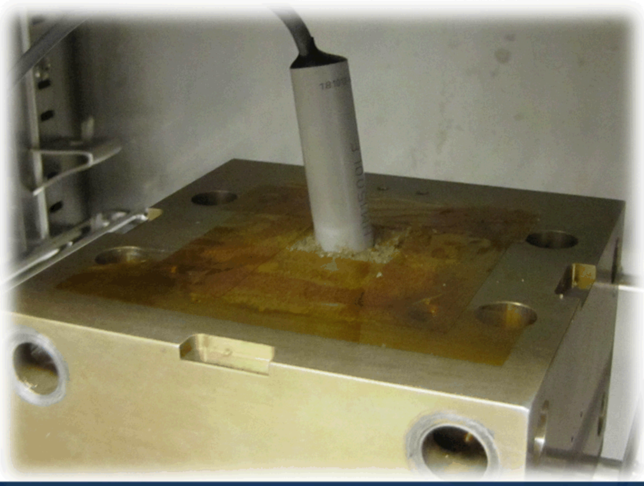



Engineering of Surrogate Encapsulants for Testing in Extreme Shock Environments



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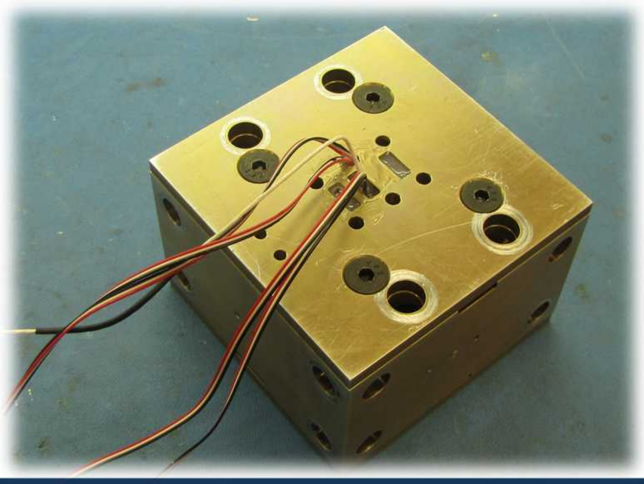
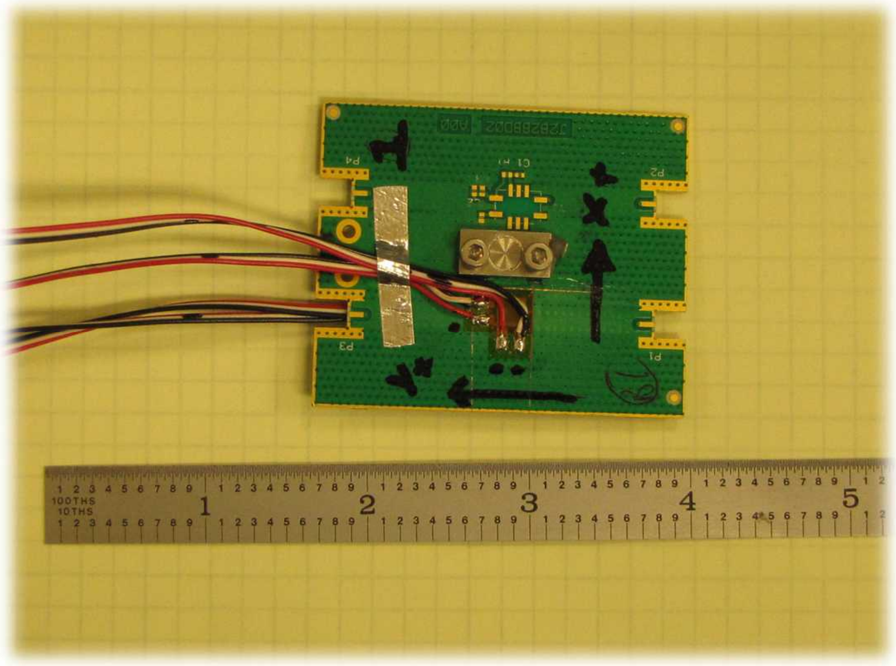
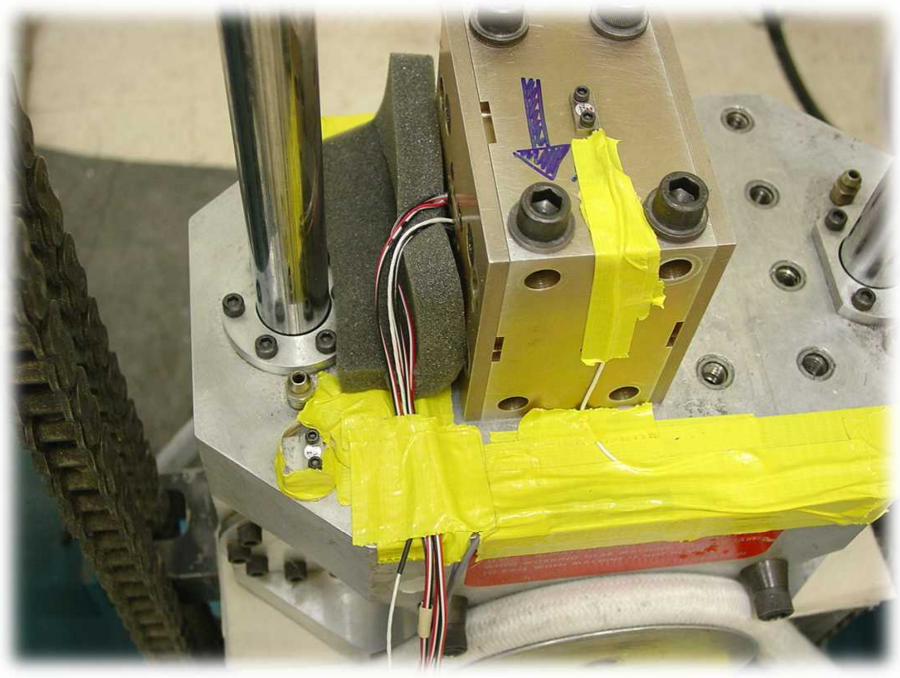


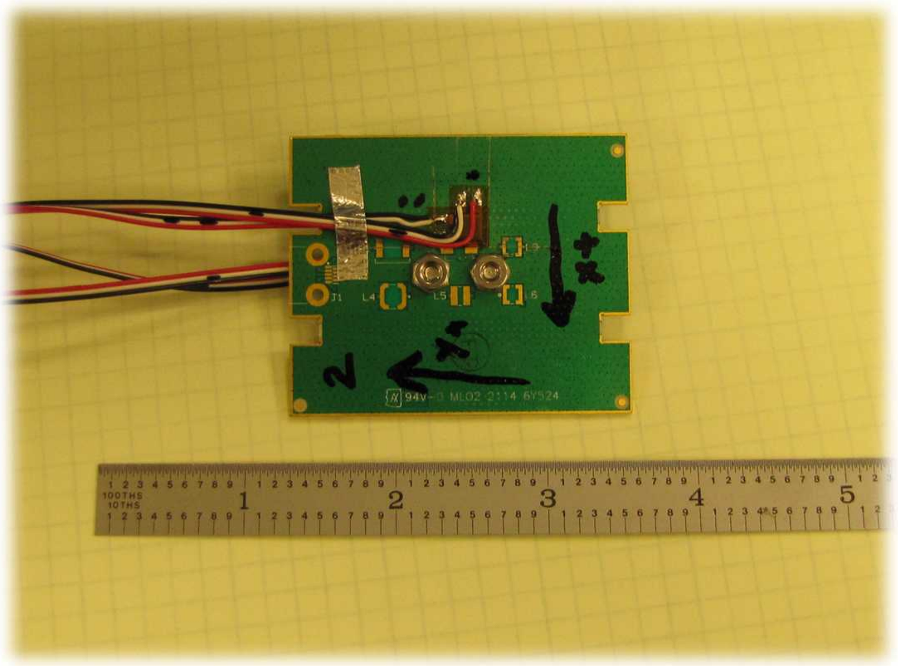
Query:

Brown Sugar has repetitively been used as a pseudo-hard pot compound for shock testing that allows for a recoverable PCB and mechanical fixture. While conducting high g shock tests on electronic assemblies, the actual integrity of brown sugar as a potting substitute was questioned. There were limited records and data three decades old that provided a limited characterization of the mechanical material properties of the cured brown sugar and its reliability during shock testing. However, the documentation was imperfect in terms of information provided.

Mission:

1. Validate earlier tests that employed the use of brown sugar as a potting surrogate
2. Compare brown sugar to an industrial-use Epoxy Potting Compound/Adhesive
3. Rate cured brown sugar on the Shore hardness scale
4. Characterize brown sugar as a potting surrogate



Testing Sequence:

1. Pot two fixtures with internal uniaxial accelerometers and biaxial strain gages on a Printed Circuit Board (PCB)
   1. Brown Sugar Potting (BSP)
   2. Industrial Potting Adhesive (HP): 3M Scotch-Weld™ DP270 Black
2. Shock each fixture ten times in axes normal and tangential to the board and measure delta acceleration between shocks with special attention to deltas following tangential axis shots.
3. Analyze data to obtain acceleration graphs and Frequency Response Functions (FRF) for use in characterization process.

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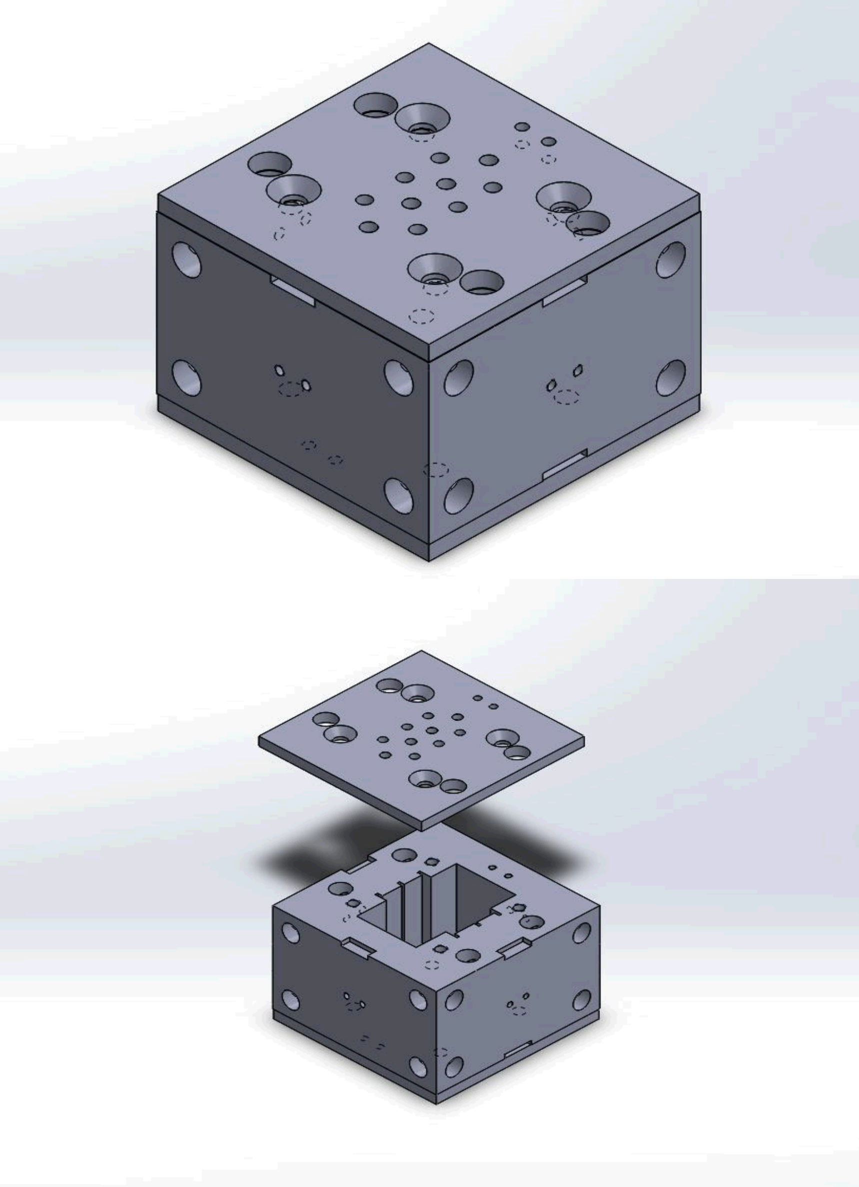
Mechanical Fixture Used For Testing:



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With Many Thanks To:

RON KAYE
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TROY SKOUSEN

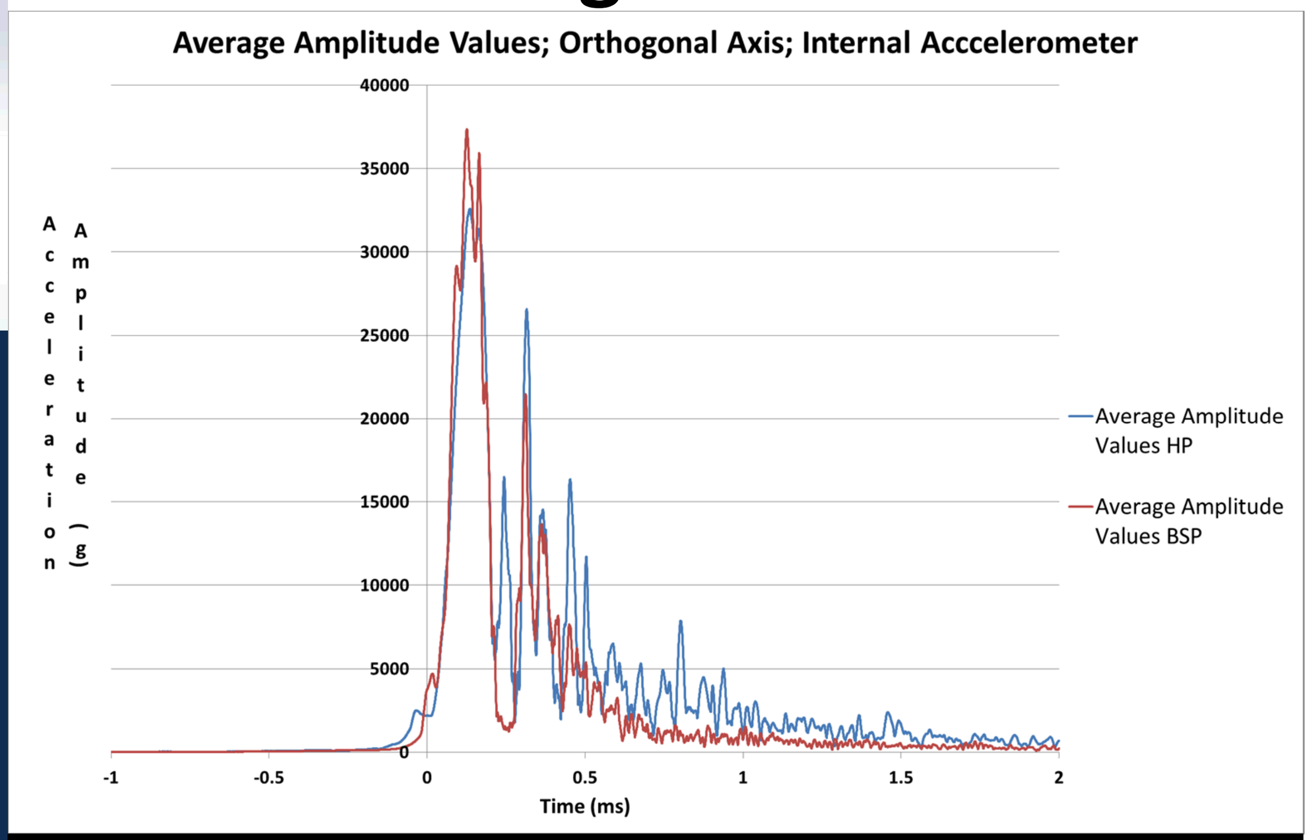
Advantages of BSP:

1. Practical use for testing and allows for recovery and visual inspection of thousands of dollars worth of PCBs, electrical components, and mechanical fixtures for a $5 bag of brown sugar.
2. Brown sugar is an easy to acquire material without the need for chemical hazard management or extensive safeguards.
3. Damps some high frequency content out of inherently high frequency shock testing which may be useful for some tests.

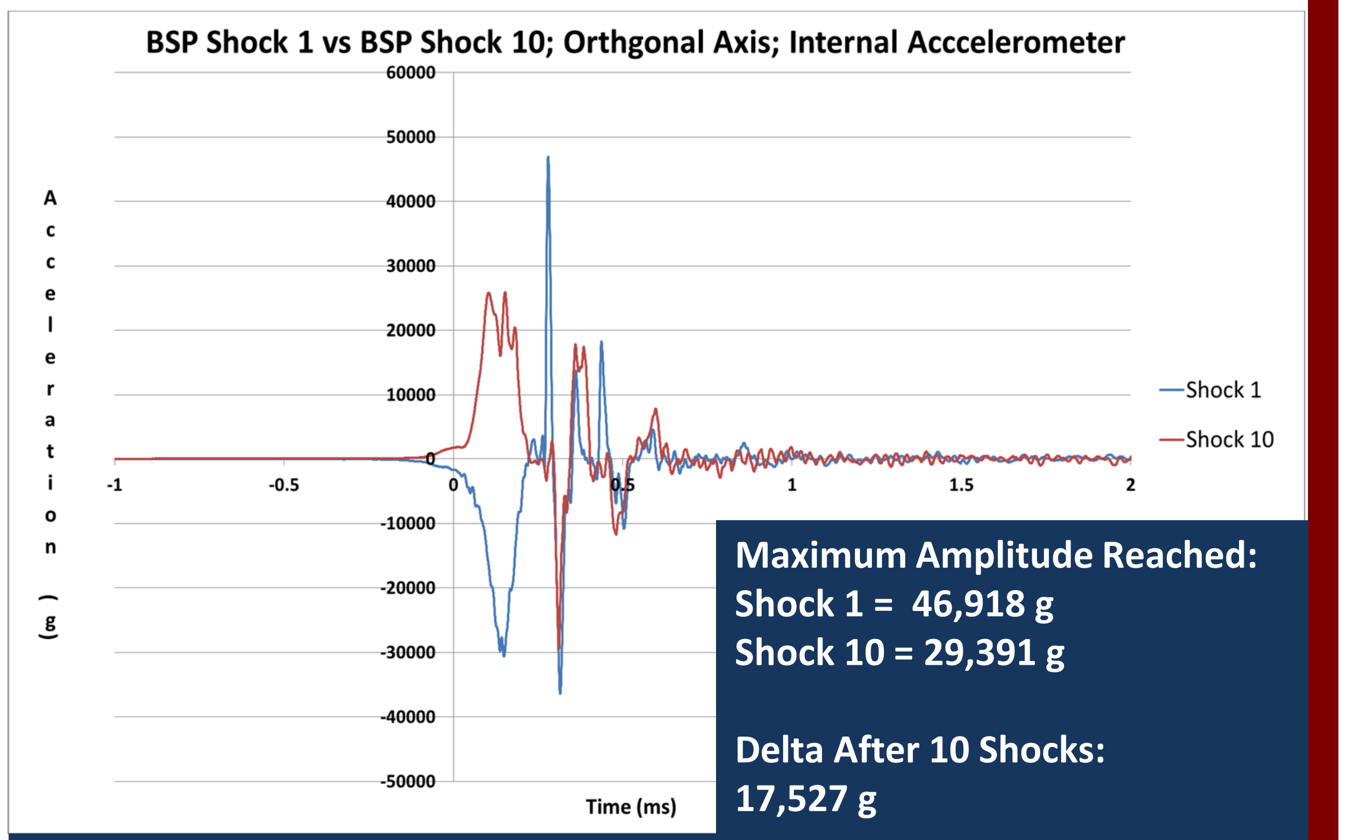
Disadvantages of BSP:

1. BSP takes one hour to complete the packing process and approximately 17 hours of cure time at 200°F. The industrial potting used took 45 minutes of preparation and 4 hours of cure time at 60°C.
2. Some components may not be able to withstand BSP cure temperatures for 17 hours.
3. Consistent data is susceptible to the reproducibility of the packing process.
4. Brown Sugar is a hygroscopic material whose mechanical properties are highly susceptible to ambient moisture levels.
5. Difficult to achieve minimum density and uniformity because of the by-hand packing process.

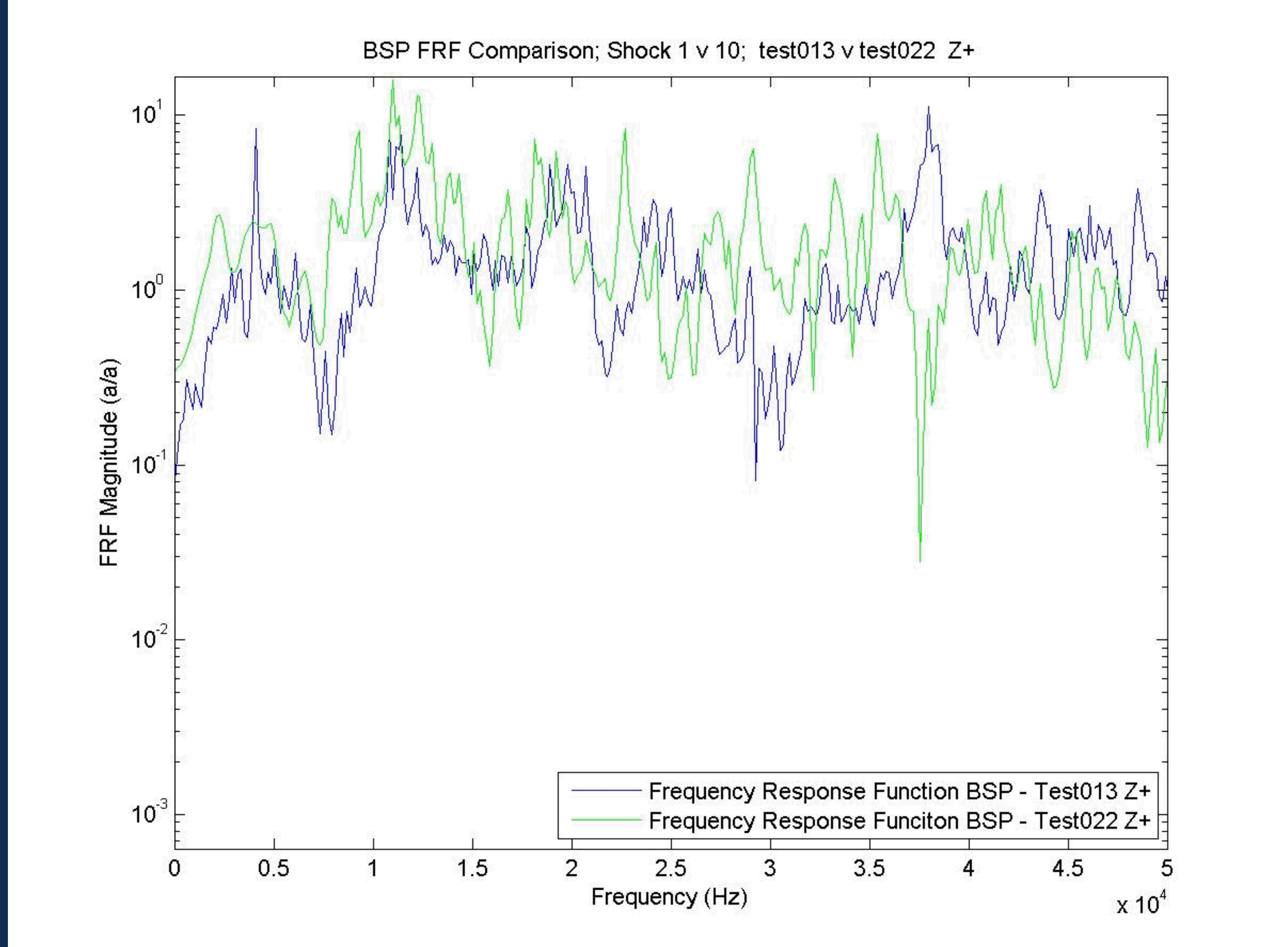
Data for Orthogonal Shock Axis:



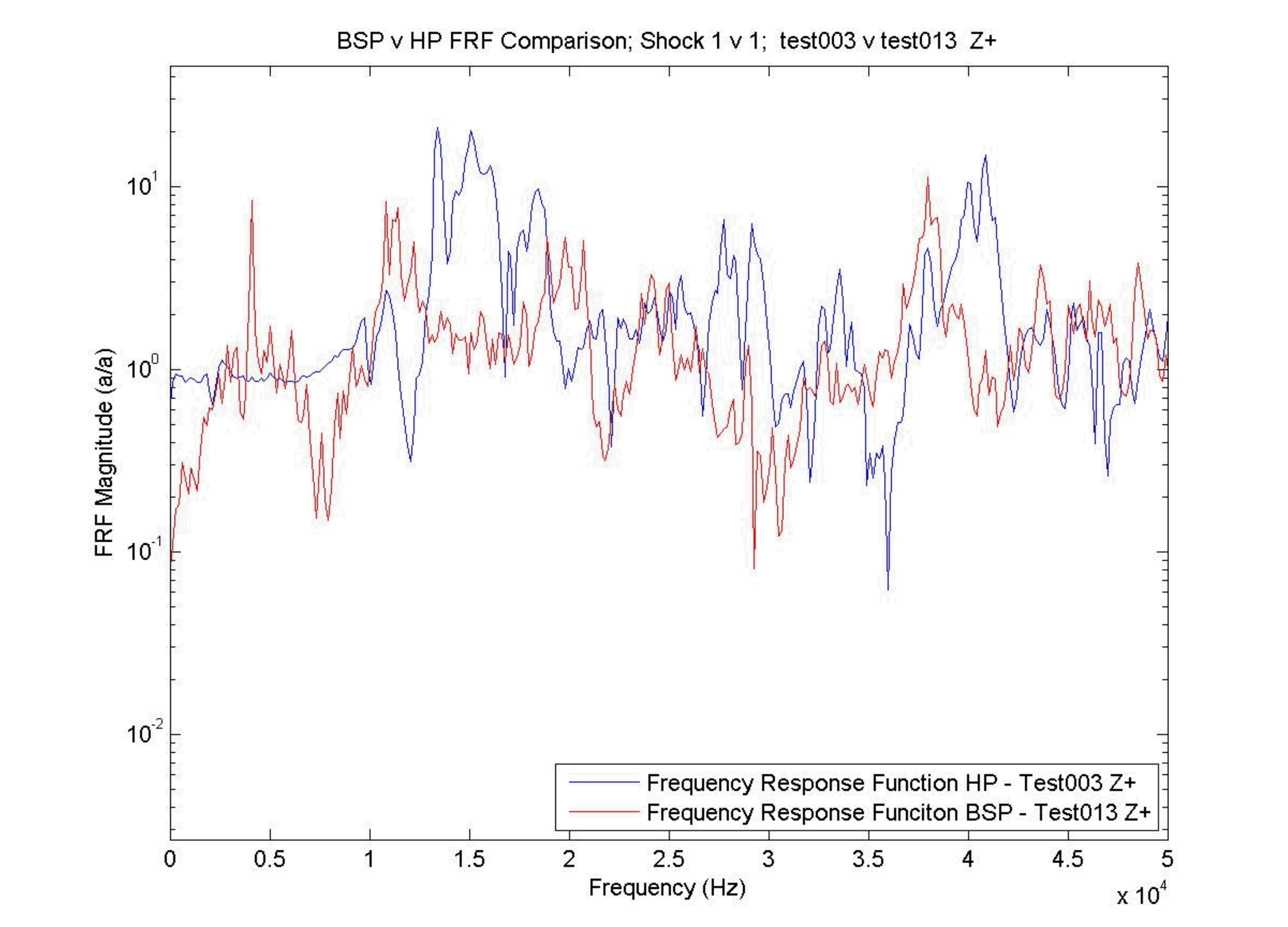
Maximum Amplitude Values:	HP = 32,588 g
	BSP = 37,357 g
Difference:	4,769 g



Maximum Input Pulse g's:	Shock 1 = 30,599 g
	Shock 10 = 25,915 g
Difference:	4,684 g



Significant change occured on the FRFs between the first and the tenth shock on the BSP. This suggests degradation of the BSP's integrity, due to shifting mode frequencies.



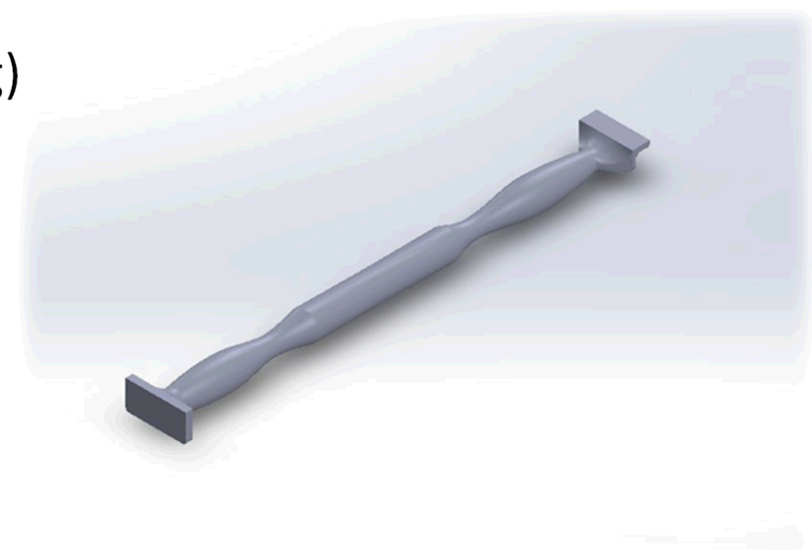
Lower modes seen in the FRF of the BSP suggest more board movement when compared to the high frequency FRF of the HP. The HP showed little delta between shots.

In Conclusion:

BSP demonstrates a usefulness in terms of recoverability of PCBs, ease of potting, and a demonstrated damping effect, it is definitely not as close to an industrial potting compound's functionality. Although extremely practical for testing, it provides a feasible process for ensuring a higher factor of safety and tolerance which, depending on time constraints and project criteria, may or may not be beneficial to the project.

Further Testing Possibilities:

1. Quasi-static testing for strength (tensile and compression and Shore rating)
2. Varying Humidity vs. Cure Temperature vs Cure Time testing for optimal performance
3. Optimization of mechanical fixture design
4. Performance at lower shock levels
5. Analyze data from strain gages to predict board deflection
6. Modal Analysis with FRFs of the mechanical unit and BSP
7. Energy Spectrum comparison and mass analysis



Testing Context:

Conventional, dissolvable potting materials do not typically have a high Shore hardness values, yet a recoverable assembly was required for the testing of these electrical components. Brown sugar has historically been used as a pseudo-hard pot that dissolves in non-damaging liquids such as water. Following high g shock testing on electronic assemblies, the shear strength and integrity of brown sugar as a potting material was called into question. BSP has always been an inexact process due to only limited documentation on the procedure. We did not know how strong or reliable the brown sugar potting would be in multiple shock events. In order to alleviate the problem and validate earlier tests, the BSP method for potting was analyzed at controlled humidity and cure time, and then compared to an industry hard pot as a control. BSP was found to be a useful potting material with acceptable results up to ~10 shots at greater than 20,000 g's and a useful, alternative potting surrogate for initial testing.

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