

December 5, 2005

Mark Merola
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Re: Final Report, Roush Anatrol Project No. A05195, "Grade Adjustment Ring Testing"

Mr. Merola:

Please accept this letter as Roush Industries' final report summarizing the testing performed by Roush and Detroit Test Labs on grade adjustment rings.

Background

The purpose of the project was to determine the effects of temperature and load on grade adjustment rings. Additionally, the durability of the rings was evaluated by tests performed at Detroit Test Labs.

Task 1 – Static Testing: Ambient Temperature, Hot, & Cold

Roush tested three grade adjustment rings, installed in a manhole cover assembly, shown in Figure 1, mounted to a fixture on a tensile test machine. Tests were performed to measure the amount of deflection of the assembly under a predetermined force, 1750 lbf, as well as to measure the amount of force required to deflect the assembly 0.25". These tests were repeated to determine the effect of temperature; three rings were tested under the following conditions: ambient temperature, 150° F, and -20° F. To achieve these temperatures, the grade adjustment rings were soaked at the desired temperature for a minimum of four hours, removed from the temperature controlled environment, installed on the fixture, and immediately tested. Once installed, the test to 1750 lbf was performed first, followed by the 0.25" displacement test on the same grade adjustment ring. The results of these tests are included below as Figures 2 and 3.



Figure 1

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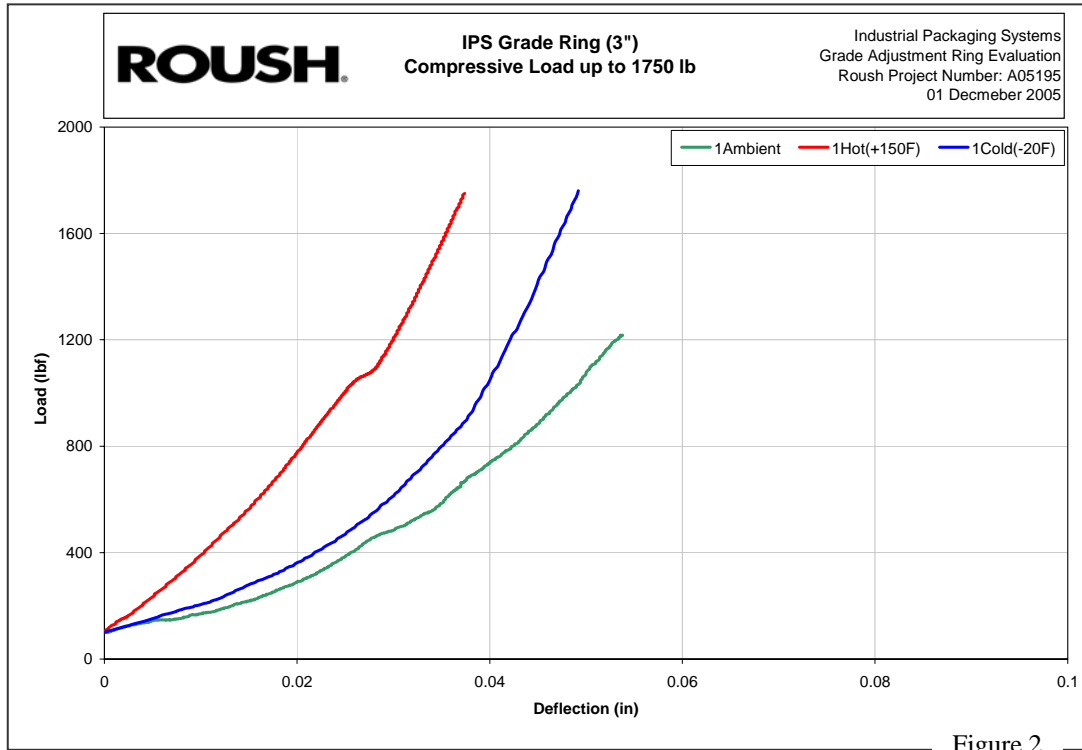


Figure 2

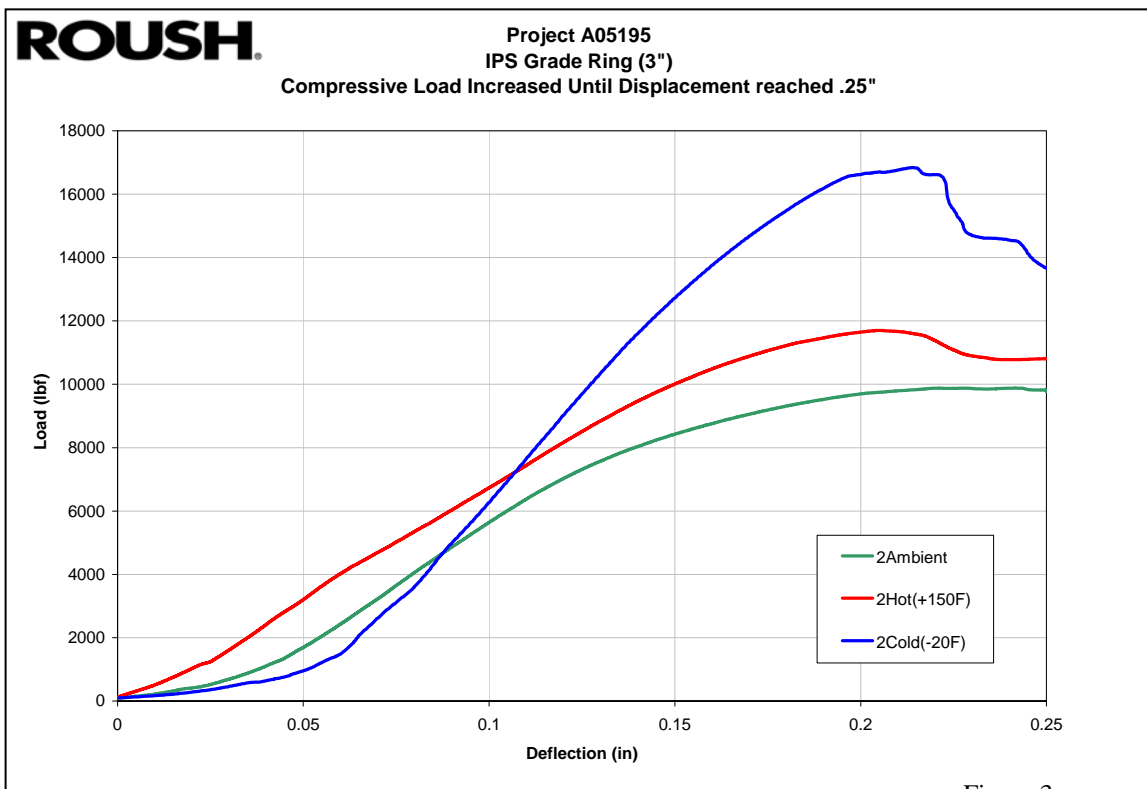


Figure 3

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Task 2 – Cyclical Testing: 1,000,000 Cycles

Cyclical testing of the grade adjustment ring was performed by Detroit Test Labs. Their report of this test is included as Appendix 1.

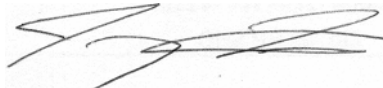
Conclusions and Recommendations

Loading the grade adjustment rings to 1750 lbf did not induce failure of the ring until the load was cycled. The sample ring that was subjected to cyclic testing did show permanent deformation at the conclusion of the test, with slight cracks visible in the areas around the deformed part of the ring. Of the rings that were compressed to 0.25", both the elevated temperature sample and the sample tested at -20° F experienced slight plastic deformation slightly past 0.2" of compression, the hot sample at nearly 12,000 lbf, the cold sample at nearly 17,000 lbf. The hot sample, while experiencing permanent deformation, did not have any visible cracks on the surface of the ring. The cold sample did have slight visible cracking on the surface of the ring around the perimeter of the ring where the deformation took place. The sample tested at ambient temperature did not permanently deform.

Mark, thank you for allowing Roush Industries to work with IPS on this study. If you have any questions about this report, please call me at 734-779-7105. My fax number is 734-779-7903, and my email address is jklipt@roushind.com.

Sincerely,

ROUSH INDUSTRIES



Jeremy Lipton
Noise and Vibration Project Engineer