WDK Testing of Novel Chemlok® Adhesives

WHITE PAPER

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ABSTRACT

Since its creation in the 1950s, Chemlok adhesives are continuously improving to address the ever-growing challenges faced by rubber-to-metal molders. Two of those challenges are pre-bake resistance and mold-fouling. Poor performance in either of these categories can limit a manufacturer's process efficiency by reducing the rate at which parts can be molded, while also making it harder for manufacturers to consistently produce quality bonded parts. This paper highlights the advantages and performance of two newly developed Chemlok adhesives, Chemlok 6224 and Chemlok 6271, which were developed to mitigate issues with pre-bake resistance and mold-fouling. These two new Chemlok adhesives were tested against the WDK guideline, a benchmark of bond performance of rubber-to-metal parts for the European automotive market. These new formulations gave, on average, high pull values and passing rubber tear values. The few encounters of failure in these tests were a result of poor phosphate treatment of the substrate, and for NR-60 in heat testing, weakening of the elastomer. These failures warrant retesting of the adhesives, and are not directly deemed as failure criteria according to WDK testing.

BACKGROUND

Pre-bake in rubber-to-metal bonding refers to the time that coated parts are left in the heated mold before rubber is introduced. Increasing an adhesive's resistance to pre-bake means having a larger window for processing time, which allows for consistency and robustness. Mold fouling is the discoloration a mold can receive due to the pre-bake process. The discoloration can be caused by sublimation of materials in the adhesive which can deposit on the walls of the mold cavity. This defect can lead to later imperfections in molded parts, reduction in ease of part removal, and loss of productivity as fouled molds must be taken out of production. Reducing the tendency of a rubber-to-metal adhesive for mold fouling can improved the productivity of a part manufacturer. As a result of both of these issues, Chemlok 6224 was developed to have improved pre-bake resistance, while Chemlok 6271 was developed to have low mold-fouling properties while still maintaining the high-level performance that Chemlok adhesives are known for.

EXPERIMENT METHODOLOGY

The testing parameters were done in accordance with the WDK No. 2000 technical guidelines established by the Association of German Rubber Manufacturing Industry [1]. The specifications are based off of ASTM D429 methods. This test is performed using three standardized types of rubber: NR-40, NR-60, and NR/BR-70. The first two are natural rubber, which primarily differ in that the -40 is softer and that -60 is harder, as the dashes signify their durometer readings. NR-60 has a much higher sulfur content, which in general makes it easier to bond than the NR-40. However, this sulfur content makes the rubber susceptible to issues with heat resistance. NR/BR-70 is a blend of natural rubber and butadiene rubber. The formulas for these rubber compounds are contained in the official documentation for this test, which can be found on the association's official website. There are four different testing environments utilized in the WDK tests: primary adhesion, heat resistance, pre-bake resistance, and steam resistance.

Regardless of testing environment, each break test is performed with a pull rate of 100 mm/min. The primary adhesion test consists of pulling the part until it breaks, without the influence of other environmental factors. For the other three tests, a pre-stressing is performed to the NR-40 and NR-60 samples at 20% elongation, while only pre-stressing the NR/BR-70 parts to 15% elongation. For steam testing, the parts are stored for 24 hours in steam phase at 95°C, and then cooled to room temperature and pulled after resting 16 hours. The pre-bake testing, is done exactly the same as the primary adhesion testing except that the metals are preheated for five minutes at 160°C before bonding. Finally, the heat test dictates that the parts be stored at 100°C for 168 hours after bonding, at which point they are cooled to room temperature for 16 hours and then pulled.

For the NR-40 and NR-60, the minimum pull value required is five MPa, with a minimum of 85% rubber failure. For the NR/BR-70, the rubber failure criteria is the same, but the minimum pull value is

increased to six MPa. This criteria must be met for all four testing environments. The test allows for multiple samples, of which the average value from all samples for a given criteria are taken and used as the final determination for pass/fail criteria. As discussed earlier, the evaluated adhesives were Chemlok 6224 and Chemlok 6271 and were tested with LORD primers Chemlok 205 and Chemosil® 211. The metals substrates evaluated were grit blasted steel and zinc phosphated steel.

RESULT ANAYLSIS

This first section of results focuses on performance of Chemlok 6224 and Chemlok 6271 against the WDK test specifications. A black line has been placed on all graphs in this report to represent the minimum required specification from the WDK guidelines. First is the full environment spectrum for both surface preparation techniques for NR-40.

Figure 1: Average pull values for Chemlok 6224 and Chemlok 6271 across all WDK tests on NR-40 for blasted and phosphate treated substrates

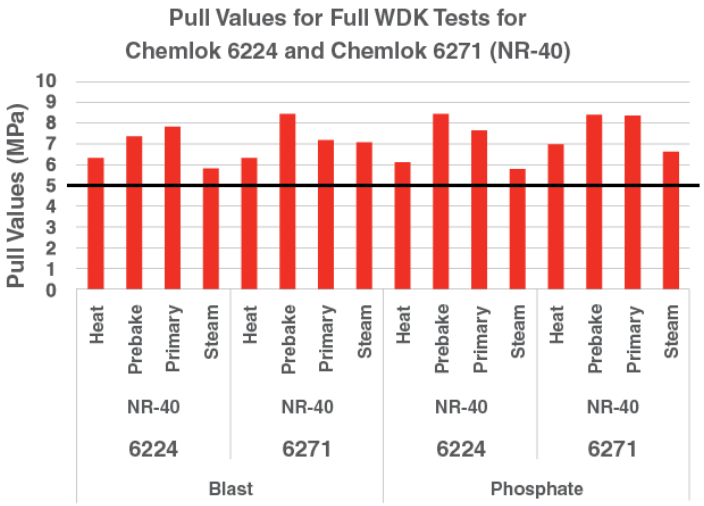
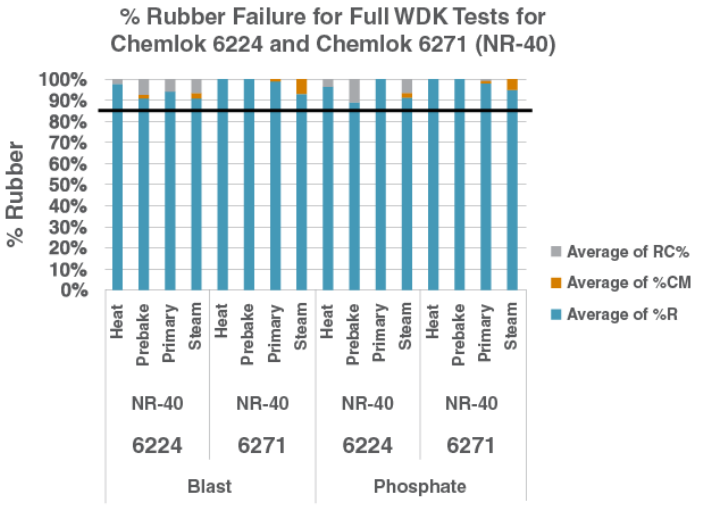


Figure 2: % rubber failure across all WDK tests for NR-40 for Chemlok 6224 and Chemlok 6271 for blasted and phosphate treated substrates



Figures 1 and 2 show that Chemlok 6224 and Chemlok 6271 pass specifications for both pull values and percentage rubber failure across all tests. This shows that these Chemlok adhesives provide excellent adhesion and environmental resistance with this elastomer. Next, the same parameters are shown except this time for NR-60.

Figure 3: Average pull values for Chemlok 6224 and Chemlok 6271 across all WDK tests on NR-60 for blasted and phosphate treated substrates

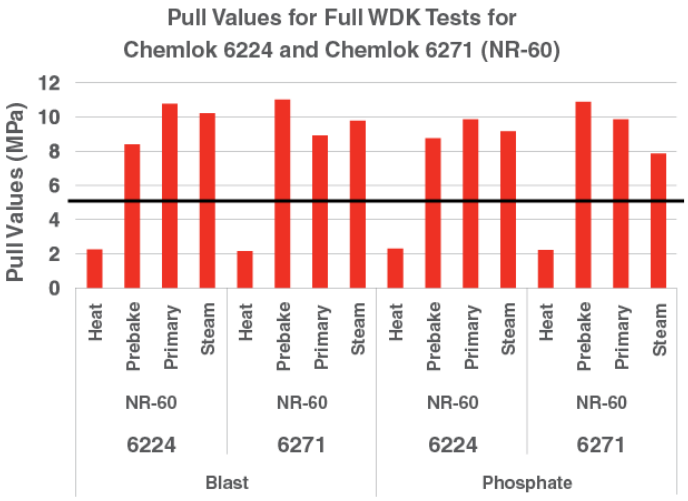


Figure 4: % rubber failure across all WDK tests for NR-60 for Chemlok 6224 and Chemlok 6271 for blasted and phosphate treated substrates

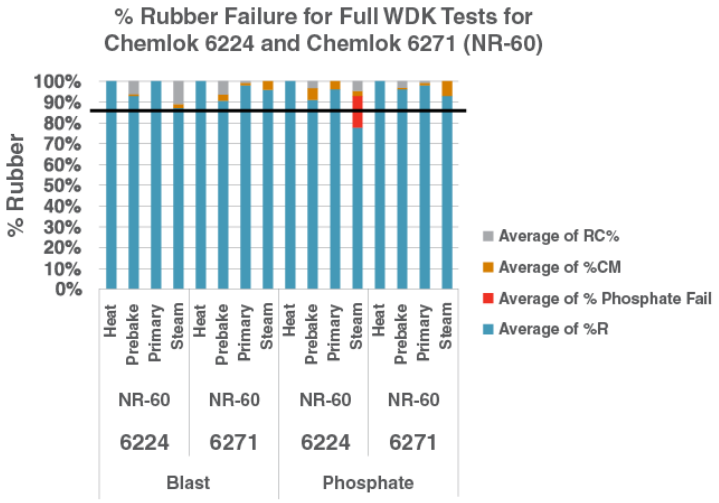


Figure 3 shows systematic failure of both Chemlok 6224 and Chemlok 6271 for the heat test. However, upon further analysis it was determined that these failures were not a result of the adhesives. The pull value failures of Figure 3 for heat testing are attributed to the NR-60 and its own resistance to heat. As stated earlier, the high sulfur content in this formulation allows it to provide easier bonding, but leaves the rubber with poor heat resistance. This is shown in Figure 4, which displays that the bond passed for all of the heat testing, as the failure was entirely

in the rubber, which is above the minimum of 85% rubber failure. Thus, the issue is in the elastomer and not the adhesive. Figure 4 shows all parameters passing, except for the steam testing for phosphated steel with Chemlok 6224. This is due to the test pieces all undergoing fracture in the phosphate treatment, which is of no fault of the adhesive. Further testing would need to be performed to determine what the actual performance of the adhesive looks like, although it should be mentioned that the adhesive passed with the blasted steel surface. Lastly are the NR/BR-70 results.

Figure 5: Average pull values for Chemlok 6224 and Chemlok 6271 across all WDK tests on NR/BR-70 for blasted and phosphate treated substrates

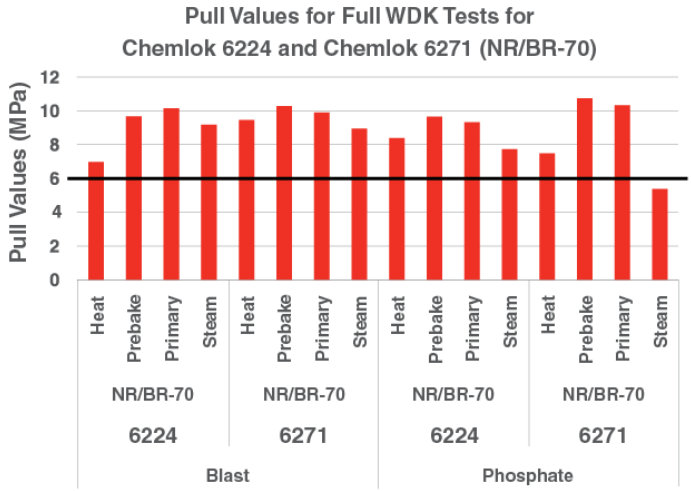
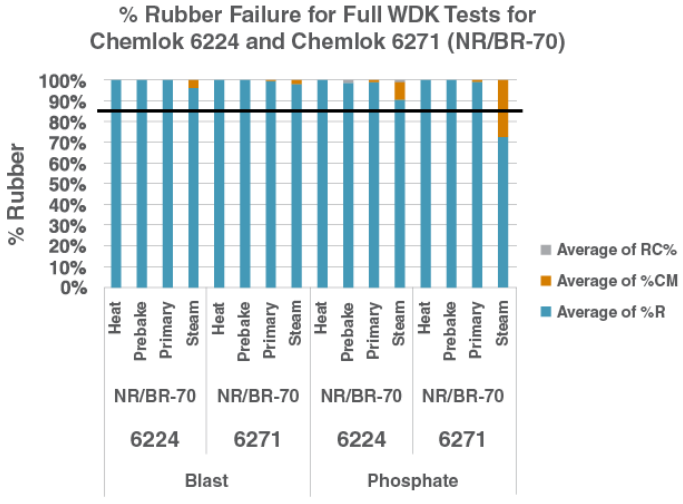


Figure 6: % rubber failure across all WDK tests for NR/BR-70 for Chemlok 6224 and Chemlok 6271 for blasted and phosphate treated substrates



Figures 5 and 6 show failure for steam testing of Chemlok 6271 on NR/BR-70, while passing all other parameters. Further testing would need to be completed to determine what the exact cause of this failure was. It should be noted that Chemlok 6271 did exhibit passing values on a blasted surface.

CONCLUSION

Both Chemlok 6224 and Chemlok 6271 have shown solid performance in WDK testing, with Chemlok 6224 in particular showing excellent pre-bake resistance. Although WDK guidelines don't test for mold-fouling, Chemlok 6271 was shown to have great performance across the range of environments tested, and consistently showed high pull values. A separate internal study was conducted on mold-fouling, in which Chemlok 6271 significantly decreased the amount of mold-fouling and the expected improvement in cycle times were achieved. Achieving high performance, while also managing to make these Chemlok adhesives part of our environmentally preferred 6000 series, is a testament to our drive to continuously improve upon our family of Chemlok adhesives. These results are for demonstrative purposes only and is recommended that customers do their own testing to confirm that these adhesives will work in their applications.

REFERENCE

[1] "Assessment of Adhesives in Use near Rubber / Composite Parts and Chassis Parts." Technische Leitlinien Shop. The Association of German Rubber Manufacturing Industry, January 2006. https://news.wdk.de/de/Technische-Leitlinien-Shop.html?group=9037&parGroup=7905.

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