

**A Review of “Evaluation
of Windshield Repairs”**

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In June 2003, windshield interlayer manufacturer Solutia, Inc. (formerly part of Monsanto) released a study entitled “Evaluation of Windshield Repairs.” The research was commissioned by the Independent Glass Association (IGA), an organization of independent glass dealers (both automotive and architectural), and the study was made available on IGA’s website (<http://www.iga.org>). IGA’s auto-related membership appears to consist largely of replacement windshield dealers and installers. Initial publication of the Solutia study on the website was accompanied by an editorial by Tim Smale, IGA’s current chief executive officer, asking the question, “How safe is windshield repair?”

According to Smale’s editorial and the introductory section of the Solutia report, research was conducted to determine the effects of windshield damage and subsequent repair on the adhesion between the windshield glass and interlayer. According to Solutia, “the ability of repaired windshields to retain the same level of safety and protection against driver injury has been subject to review since the resin repair system was developed” (p. 2). More specifically, “Testing focused [sic] on reviewing conformance of post repaired windscreens with ANSI/SAE Z26.1 impact test 12.” Note that this is a test intended to minimize the likelihood of complete penetration of the windshield by a large projectile.

Unfortunately, the Solutia study and Smale’s editorial do nothing to enlighten this issue. Both reflect apparent ignorance of scientific work that has gone before. Moreover, the Solutia study was carried out with little regard for scientific rigor. In fact, Solutia never conducted the ANSI tests that were the supposed focus of its research.

Prior Research

A decade ago, the National Glass Association communicated to the Insurance Institute for Highway Safety a concern about the safety of repaired windshields, arguing that the exposure of the plastic interlayer to moisture would reduce the bond with interior glass and allow increased spalling. The concern arises because it was hypothesized that injuries, particularly to the face and eyes, could result from the small shards of glass that could be dislodged.

In response to that communication, the Institute reviewed the injury literature and interviewed a number of medical practitioners to determine the extent to which such injuries from windshield glass were a problem. The review found that the principal risk of injury from windshields occurs from contact with glass during collisions. There was a complete absence of published literature documenting the existence of windshield-related facial/eye injuries in real-world noncollision events, that is, through windshield spalling. From this, the Institute concluded that injuries from spalling glass in noncollision events were not a problem. The bibliography for the Institute’s review is attached.

Next, the Institute conducted its own study to ascertain whether exposure to moisture increased the likelihood of spalling in damaged windshields that subsequently are involved in typical impacts by

roadside debris. Whole windshields with repairable damage to exterior glass layers were immersed in water for a week. The windshields were purchased new, and star-pattern damage was induced using a center punch. Without any repair, the damaged areas of the soaked windshields were subjected to high-speed impacts with a small steel ball intended to simulate severe impacts from road debris. The median impact speed at which glass began to spall from the interior glass layer was estimated and compared with the impact speed at which glass loss occurred from similarly damaged windshields that had not been soaked in water. If moisture reduces glass adhesion significantly, then one would expect an impact with external debris to cause interior glass spalling at a lower impact speed in the moisture-exposed samples than in the dry control samples. The results showed no significant difference in the impact speed required to produce glass dislodgment (estimated median speed of 176 km/h for soaked windshields, 169 km/h for dry windshields), despite the exposure to much more moisture than could occur to windshields on vehicles. This research is described in more detail in “Study Evaluates Water Exposure of Damaged Automotive Windshield Glass and Spalling from Subsequent Impacts” by Lund and Powell (1999), published in the National Glass Association’s journal, *Autoglass*.

Thus, the Institute’s research of a decade ago indicated that injuries caused by glass spalling from the interior layer of a laminated windshield in a typical noncollision impact with road debris is not a documented problem. Cases are absent from the published literature, and a survey of experts in emergency medicine failed to yield a single case. In addition, Institute research showed conclusively that exposing a repairable windshield to moisture does not increase the likelihood of glass spalling from typical noncollision impacts.

The fact that neither Solutia nor Smale refer to this research or discuss the Solutia study’s relevance to the prior research suggests either ignorance or bias.

Solutia’s Test Procedure and Results

Solutia tested seven windshields of unspecified origin and age that had been removed from vehicles. In all seven cases, the bull’s eye damage that was the subject of testing already was present on the windshield, presumably incurred at some point during normal use of the vehicle. Nondestructive measurements of interlayer moisture content were made using a spectrophotometer. Glass-to-interlayer adhesion levels were measured using a “pummel” test, the procedure for which is not described in detail in the report. The pummel test is an industry standard test of quality assurance used regularly by laminated glass manufacturers, but it is not a part of the ANSI/SAE Z26.1 standard for laminated safety glazing. Instead, the pummel test consists of chilling a glass sample to 0 degrees Fahrenheit and then repeatedly striking it by hand with a ball-peen hammer over an approximate 40 square inch area. Test results, determined by observing the amount of interlayer exposed as a result of the impacts, are expressed

on a 0-9 scale, with 0 indicating a total lack of glass particles left adhering to the interlayer. Pummel testing was conducted on each windshield at both the damaged and repaired area and at an undamaged baseline location. No reason is given for using the pummel test instead of the ANSI/SAE Z26.1 impact test 12, even though the latter was introduced as the focus of Solutia testing.

The moisture content of six of the seven windshield interlayers was found to be 5 to 96 percent higher in the damaged areas than in undamaged areas of the windshields. The remaining sample showed no increase in moisture content in the damaged area. Results of the pummel testing indicated that, in general, adhesion scores on the 0-9 scale were lower in the repaired areas than in the unrepaired areas.

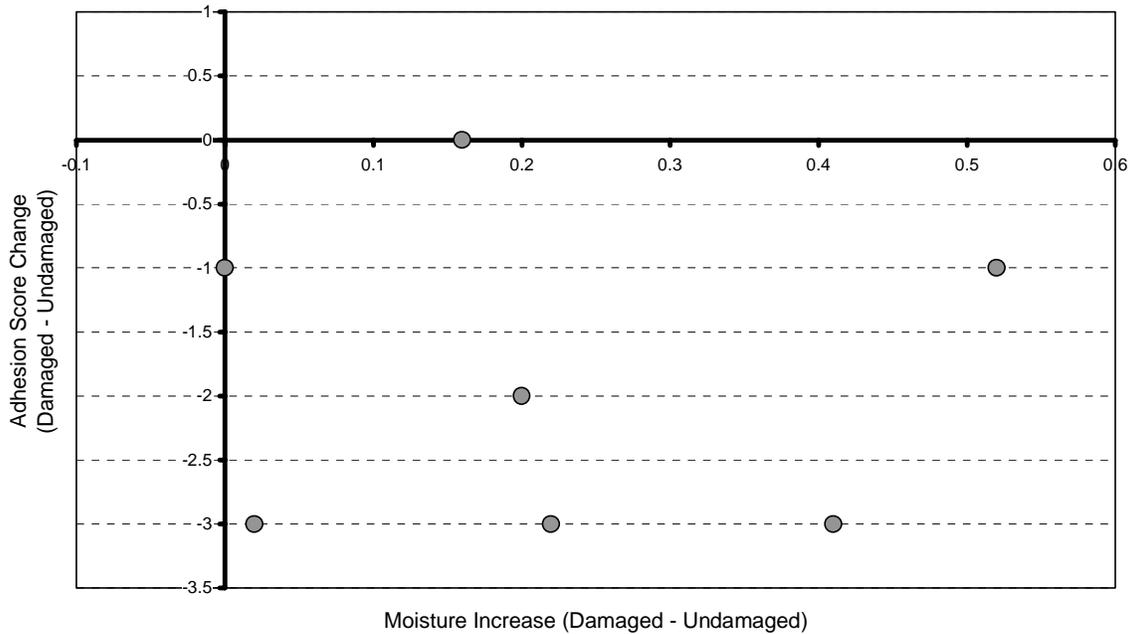
Comments on the Solutia Study

Solutia summarizes the findings of its study as follows: “Moisture infusion into the PVB interlayer of a broken windshield was shown to reduce the adhesion between the glass and the PVB in that region, thereby adding risk of injury from glass spalling during subsequent impacts.” This conclusion is wrong in two fundamental ways.

First, it does not show that there is added risk of injury from glass spalling. In fact, the report does not document that there is *any* injury risk from windshield spalling under any circumstances in noncollision events. Moreover, Solutia did not conduct the test (ANSI/SAE Z26.1 impact test 12) introduced as the subject of its research. Instead, Solutia used the pummel test, which is ill suited to judge the safety of windshield repair. The pummel test may measure how well glass adheres to the polyvinyl butyral (PVB) interlayer when tested to destruction, but it does not necessarily measure the probability that spalling will occur on impacts with road debris. Thus, the study offers no evidence that windshield repairs are compromising the safety of windshields on the road.

Second, the results are not convincing about the relationship of moisture infusion to adhesion as measured in the pummel test. Figure 1 charts the difference in pummel test ratings between damaged/repaired areas of windshields and undamaged areas, as a function of the difference in measured moisture between those areas. It is apparent that there is no relationship between moisture differences and glass adhesion reductions for the seven test windshields. Remarkably, one of the worst performing windshield repairs (a score of 0 in the pummel test) had a moisture level within design specifications for new windshields (0.44 percent) and nearly identical to the moisture level of its nondamaged area (0.42 percent), which received a score of 3 in the pummel test. This is the point (0.02, -3) plotted in the figure. Clearly, any reduction in glass adhesion in the damaged areas was not due to moisture differences. (In this figure, the absolute change in moisture content is graphed, but the figure would be similar if the percentage change in moisture content were shown on the X-axis.)

Figure 1
Change in Glass Adhesion to Inner Windshield Layer as a
Function of Moisture Increase Measured at Damaged Site



This pattern of results suggests that other aspects of the windshields, not the measured moisture infusion, account for the difference in adhesion rates between the damaged/repared areas and the undamaged areas. Unfortunately, an absence of documentation regarding Solutia’s test samples and procedures makes it difficult to know what accounts for the differences. For example:

- The age and condition of the windshields is unknown. Were the damaged windshields properly supported during transit or could the differences relate to stress and twisting of the windshields in the damaged areas during transit? Damaged windshields that are still in cars have some resistance to such stresses because they are still securely mounted.
- The extent, size, and shape of the existing damage sites are undocumented.
- The locations of damaged sites and of baseline undamaged sites are undocumented. This becomes important if testing is conducted near the edge of the windshield, where interlayer degradation is known to occur with age.
- The quality and method of repair is undocumented. A problem was noted in repairing line cracks in the unsupported windshields. Could the lack of support also have affected the strength of the repairs that were conducted?
- The method of controlling for experimenter bias in the pummel test is unspecified. The pummel test is somewhat subjective in that the glass is pounded by the hand and at the judgment of the tester. In such conditions, the tester should be blind to the hypotheses of the study. Better still

would be a test procedure that subjects the glass samples to standardized procedures with objectively measurable results.

The Solutia study adds nothing to the current knowledge about the relationship between windshield repairs and safety in subsequent, noncollision impacts with roadside debris. Moreover, the major hypothesis of the study, that glass adhesion in damaged windshields is affected by moisture infusion, is not substantiated by the results.

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