D22 Friction Tire Testing of a Run-Flat Condition Sport Utility Vehicle (SUV) Tire

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After attending this presentation, attendees will better understand the value of dynamic tire friction testing as a tool for collecting data that relates tire inflation pressure to the rolling friction of a run-flat SUV tire.

This presentation will impact the forensic science community by providing data for speed calculations at the start and end of tire friction marks. This data will help traffic collision reconstructionists understand the effect of tire inflation (e.g., the run-flat condition of a rear tire) on vehicle (and occupant) kinematics and dynamics. These results are also important to biomechanical engineers, because the literature documents increased likelihood of vehicle instability and rollovers, and increased likelihood and severity of injury as a result of loss of tire pressure and/or failure.

Collision Overview: On a desert highway, the right rear tire of an SUV catastrophically failed at approximately 70mph. Pre-rollover tire pressure loss resulted in an unintended vehicle heading change. Right oversteering driver input resulted in clockwise yaw, but then left oversteering driver input resulted in counterclockwise yaw. Front tire friction marks were documented. The SUV traversed down a dirt and rock embankment. The SUV flipped, passenger-side leading, at about 40mph and rolled uphill 3¼ times over a distance of approximately 125ft. The SUV came to rest on its wheels.

The female driver sustained fatal head, chest, and abdominal injuries with extensive musculoskeletal fractures. The left second-row, ejected male passenger sustained diffuse axonal brain injury, neck fracture, and chest injuries with residual impairment. These injuries most likely occurred inside the vehicle or during ejection.

Tire Analysis: The subject vehicle and failed tire were inspected by tire experts who agreed with the sidewall failure mechanism (i.e., a complete circumferential separation of the outer sidewall from the tire casing due to operation while severely underinflated). A tear observed on the failed tire inner sidewall adjacent to the tread belt was hypothesized as the source of the air pressure loss. In this instance, it was unknown how long it took the tire to deflate and cause the outer sidewall failure.

Dynamic friction testing was conducted with an exemplar SUV equipped with a new 275/60R16 tire installed on the right rear wheel. Tests were performed on a rough and weathered asphalt roadway. The test vehicle was accelerated to a speed of 39mph to 53mph and then allowed to coast (i.e., without brake application) to speeds between 16mph and 22mph. The test matrix included two test runs each for both directions of the roadway. A baseline test of the vehicle's overall rolling friction (including air resistance) was determined with all tires inflated to 38psi. Then, the air pressure of the right rear tire was bled out to 20psi, 10psi, and about 3psi, respectively. The four test runs and resulting deceleration rates were averaged for each test tire pressure. Vehicle speed was measured at 20Hz with a Racelogic VBox II Lite.

The test tire was documented with: (1) an exterior-mounted video camera that captured the tire flex and road noise; and, (2) an on-board video camera that captured steering wheel and operator motion due to the low-pressure right rear tire.

Results: The test data was analyzed using the VBox Tools software. The overall road friction (including air resistance) of the test SUV was -0.0263g at 38psi and 20psi, -0.0325g at 10psi, and -0.0435g at about 3psi. Despite the rough and weathered test roadway asphalt, the steering wheel did not appear to demonstrate significant rotation or vibration as a result of the low pressure in the test tire; however, the noise level recorded by the external video camera, as well as that detected by the test vehicle operator, was remarkably loud inside the vehicle cabin. Surprisingly, the outer sidewall temperature of the test tire with about 3psi was too hot to touch immediately after testing. Test results demonstrated the value of dynamic friction tire testing and the results show that overall road friction increases with decreasing tire pressure.

Run-Flat, Friction, Rollover

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