C29 Tour Bus Limit Handling Degradation With Suspension Modification

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The goal of this presentation is to show the results of how modification to bus suspension affects controllability.

This presentation will impact the forensic science community by defining the definition of bus limit handling with and without suspension modifications.

A 29-passenger tour bus suspension was modified to increase the ride comfort. The rear leaf spring normally has a steel shackle for rear attachment. The shackle was replaced by a stack of rubberized material that would not only support the spring, but would absorb some of the road vibration. Another result of the modification is that the rear of the rear leaf spring could also have up to an inch of additional lateral motion. The rear spring support loses some of its stiffness. The additional lateral motion of the rear axle during a turn, particularly at higher turning rates, can reduce the controllability of the overall bus.

A series of track tests were performed to evaluate and quantify the results of the suspension modification. The bus was fully instrumented to measure both control inputs and dynamic outputs. The bus was equipped with outriggers for safety. Movie cameras, both onboard and off, documented the tests. The vehicle was equipped with a controller that could be programmed to input steering. Braking and throttle was controlled by the driver. The measurements included 3-axis linear acceleration, 3-axis angular acceleration, velocity, steer input, braking input, and throttle input, as well as ride height at each wheel and rear axle lateral location.

To evaluate the controllability of the vehicle in near limit turning, two basic tests were performed. A modified Federal Motor Vehicle Safety Standard (FMVSS) 126 and J turn. The FMVSS 126 is a standard to evaluate the effectiveness of the directional stability control for vehicles. While this bus was above the weight limit for direct application of this standard, it was useful for turning evaluation. The basic standard requires some preliminary warm up and tire break in tests. The turning is basically a modified sine wave with a dwell on the second portion of the turn when the steering is at its maximum. The J turns are simply a turn in one direction. The severity of the turns is increased until a limit is reached.

Side slip in vehicle dynamics is the angle between the heading of the vehicle and the direction of travel. In addition to the traditional performance criteria of FMVSS 126, the duration and magnitude of the side slip was a measure of control performance. FMVSS 126 has as criteria the return-of-Yaw rate after the steer input at milestone times.

The attachment of a lateral bar from the frame to the axle (panhard rod) is designed to limit the lateral rear axle motion. The vehicle was also tested with a panhard rod attached in the case of the rubberized modification.

Tests were conducted on a production suspension with a steel shackle, the vehicle with rubber support at the rear, and the vehicle with the rear rubber supports and a panhard rod.

The bus was most controllable and passed all the FMVSS 126 criteria when in the original design configuration with the steel shackle. The addition of the rubberized rear attachment significantly reduced the limit turning performance of the vehicle with failure of the FMVSS 126. The panhard rod improved the performance of the rubberized suspension with some of the FMVSS 126 criteria passing.

The conclusion is that rubberized suspension that allows approximately one inch of lateral motion of the rear of the rear leaf spring support can lead to degraded limit turning performance.

Bus Limit Performance, Bus Track Tests, Bus Handling Testing

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