

produce two-wheel lift, the MES is increased to 47.5 mph. If the test with MES equal to 47.5 mph does not produce two-wheel lift, the MES is increased to 50 mph (the maximum MES used for Fishhook maneuver testing). If no two-wheel lift is observed during the left-right sequence, the right-left test sequence is initiated using the same process as the left-right sequence. If any test in the Supplemental Procedure Part 2 test series produces two-wheel lift, a new set of tires is installed on the vehicle, and the procedure described Section 3.2.3.3 is implemented.

A test series is terminated if rim-to-pavement contact or tire debanding is observed during any test performed with either test sequence. A test series is deemed complete if both test sequences within the series have been performed at the maximum maneuver entrance speed without two-wheel lift. The flowchart presented in Figure I.13 describes the sequence of events for the Supplemental Procedure Part 2.

3.2.3.3 Supplemental Procedure Part 3

Following the tire scrub-in procedure outlined in Section 4.6, two tests are performed with handwheel angles equal to $\delta_{\text{Fishhook (Supplemental)}}$. The steering combination that produced two-wheel lift during Supplemental Procedure Part 2 testing is used (*i.e.*, either left-right or right-left). The first test is to be performed at a MES of 35 mph. This test is performed to ensure any mold sheen remaining from the tire break-in procedure has been removed from the tires. The second test is to be performed at the MES that had produced two-wheel lift during Supplemental Procedure Part 2 testing (*i.e.*, with the previous tire set). If two-wheel lift is produced during the test performed with handwheel angles equal to $\delta_{\text{Fishhook (Supplemental)}}$, the tip-up will be reported in the vehicle's NCAP Rollover Resistance Rating and the test series is deemed complete. If two-wheel lift is *not* produced and the MES is 45 mph, the MES is increased to 47.5 mph. If two-wheel lift is not produced and the MES is 47.5 mph, the MES is increased to 50 mph. If two-wheel lift is produced during any test performed during Supplemental Procedure Part 3, the tip-up will be reported in the vehicle's NCAP Rollover Resistance Rating and the test series is deemed complete. If two-wheel lift is *not* produced during Supplemental Procedure Part 3, the test series is deemed complete and no tip-up will be reported in the vehicle's NCAP Rollover Resistance Rating.

A test series is terminated if rim-to-pavement contact or tire debanding is observed during any Supplemental Procedure Part 3 test. The flowchart presented in Figure I.14 describes the sequence of events for the Supplemental Procedure Part 3.

3.2.4 Handwheel Inputs

3.2.4.1 Steering Rate

The handwheel rates of the initial steer and countersteer steering ramps are always to be performed with nominal steering rates of 720 degrees per second, regardless of what steering scalar is used.

3.2.4.2 Dwell Time

The Fishhook maneuver is designed to maximize the roll motion of the test vehicle. When left-right steering is used, this is accomplished by:

1. Steering the vehicle with an input equal to $\delta_{\text{Fishhook (Default)}}$ OR $\delta_{\text{Fishhook (Supplemental)}}$
2. Waiting until the vehicle achieves maximum roll angle.
3. Reversing the direction of steer
4. Steering the vehicle with an input equal to $-\delta_{\text{Fishhook (Default)}}$ OR $-\delta_{\text{Fishhook (Supplemental)}}$

When right-left steering is used, the sign conventions indicated in Steps 1 and 4 above are switched from positive to negative (*i.e.*, for Step 1) or from negative to positive (*i.e.*, for Step 4).

Dwell time is defined as the time from the completion of the initial steering ramp to the initiation of the steering reversal. A roll rate "Window Comparator" is used to determine when the vehicle has achieved maximum roll angle. Since the programmable steering machine used by NHTSA has a mechanical overshoot after completion of the initial steer, dwell time is not measured directly with handwheel angle data. Rather, two signals output from the steering machine are used: "Handwheel Start" and "Roll Flag".

3.2.4.2.1 Steering Machine Window Comparator

As indicated in Figure I.10, Fishhook maneuver steering reversals are commanded after the completion of the initial steering ramp and when the roll rate of the vehicle is very close to zero (because it is the derivative of roll angle, when roll rate is equal to zero at this point, roll angle is at its maximum). To minimize the likelihood of erroneous reversals, the reversals occur when the roll rate signal transmitted from a sensor positioned near the test vehicle's center of gravity enters the window comparator. The window comparator is defined as ± 1.5 degrees per second, regardless of what steering scalar was used.

Examples: If an initial steer to the left is input, the reversal is initiated when the roll velocity of the vehicle is equal to 1.5 degrees per second. If an initial steer to the right is input, the reversal is initiated when the roll velocity of the vehicle is equal to -1.5 degrees per second.

3.2.4.2.2 Handwheel Command Flag

The programmable steering machine used by NHTSA outputs a "Handwheel Command Flag" signal based on the machine's internal clock. The output of the Handwheel Command Flag signal ranges from 0 to 10 volts, and is binary. The signal is high (10 volts) when the steering machine is in the process of executing a commanded input, or low (0 volts) when the machine is not in use or a pause is commanded during the execution of a commanded input, as shown in Figure I.10. When the pause ends, and execution of the commanded steering inputs are resumed, the Handwheel Command Flag signal is once again set high. In a Fishhook maneuver, the duration of the pause is the dwell time.

3.2.4.2.3 Roll Rate Flag

The "Roll Rate Flag" signal output by the programmable steering machine used by

NHTSA is monitored. Like that of the Handwheel Command Flag channel, the Roll Rate Flag output ranges from 0 to 10 volts, and is binary. The signal is high (10 volts) when the roll rate of the test vehicle is within the window comparator, or low (0 volts) when roll rate is outside the window comparator, as shown in Figure I.10.

Fishhook maneuver steering reversals are to be initiated by the steering machine within 10 milliseconds of the roll rate entering the window comparator. Initiation of the steering reversal is defined as the instant the steering machine sets the Roll Rate Flag signal high.

Note: After completion of the initial steer, the instants that the steering machine sets the Roll Rate Flag and Handwheel Command Flag signals high should coincide.

3.2.4.3 Excessive Steering

In some cases, the magnitude of $\delta_{\text{Fishhook (Default)}}$ used during the Default Procedure may be so great that the vehicle reaches maximum roll angle before completion of the initial steer. This is defined as excessive steering; *i.e.*, the vehicle cannot respond to the entire commanded steering input.

Excessive steering is also said to occur if the dwell time of a Fishhook test performed with the Default Procedure results in a dwell time less than 80 milliseconds. The mechanical overshoot of the steering machine that occurs after completion of the initial steer can prohibit the machine from accurately executing dwell times less than approximately 80 milliseconds. In such cases, the effect of the overshoot is that the actual dwell time is equal to zero (an immediate steering reversal).

NHTSA's experience with the Fishhook maneuver has demonstrated the effect of excessive steering on dynamic rollover resistance is vehicle-dependent. While it may not allow the roll motion of some test vehicles to be maximized, excessive steering has been shown to contribute to an increased tip-up propensity in others. For this reason, a test sequence for which excessive steering is observed should *not* be terminated. Testing should proceed as outlined in Section 3.2.2, Default Procedure. If two-wheel lift is not observed during either Default Procedure test sequence, the Supplemental Procedure beginning at Part 2, described in Section 3.2.3.2, is performed.

4.0 Items Pertaining to Test Conduct

4.1 Definition of Two-Wheel Lift

Two-wheel lift is defined as the occurrence of at least two inches of simultaneous lift of the inside wheels from the test surface. NHTSA does not consider two-wheel lift less than two inches when calculating a vehicle's NCAP rollover resistance rating. Two-wheel lift great enough to require outriggers to suppress further roll motion is to be reported simply as "two-wheel lift" as long as at least two inches of simultaneous two-wheel lift occurs before outrigger contact with the ground is made.

4.2 Vehicle Test Configurations

4.2.1 Load Configurations

All vehicles are to be evaluated with one of the two load configurations previously defined in Section 2.1.