locks, or when the pedal force reaches 1000 N (225 lbs), or 0.1 seconds after first axle lockup, whichever occurs first." This modification of the language should avoid the problems cited by the commenters.

BMW requested that the wheel lock sequence test be run at speeds of 50 km/ h, claiming that the conditions proposed in the 1991 SNPRM demand a higher initial speed and brake pedal application rate than the OICA proposal. NHTSA believes that the proposed test speed of 65 km is appropriate for safety and consistent with ECE R13H. BMW neither raised a safety concern nor provided any documentation to support its request to lower the test speed. Accordingly, the test speed for the wheel lock sequence test is adopted as proposed.

Ford, Chrysler, and MVMA requested deleting the speed channel filtering test condition or clarifying it so that it applies only to analog instrumentation methods. They stated that a low pass filter, having a low cut-off frequency is applicable to analog data recording but not digital data recording.

NHTSA has decided to clarify S7.2.3(g) and (h) so that it refers only to analog instrumentation. These sections address the automatic recording of data and speed channel filtration and are unnecessary for digital data recording.

In the 1991 SNPRM (Notice 5), NHTSA proposed a modified wheel lock sequence test for a vehicle equipped with an antilock brake system on one or both axles. Under this proposal, an ABS equipped vehicle would have to be capable of stopping on a surface with a transition from a high PFC to a low PFC without wheel lockup exceeding 0.1 seconds, after decelerating in a hard braking from 100 km/g to a stop. The agency believed that this would test the ABS's ability to compensate for changes in surface quality and conditions encountered in everyday driving. The agency requested comment about the need to adopt other aspects of Annex 13 addressing braking efficiency and split coefficient of friction surfaces, as more advanced ABS are sold in the United States

MVMA and Ford requested that vehicles with axles not directly controlled by ABS be allowed to be certified as complying with the wheel lock sequence test. They incorrectly stated that while the 1991 SNPRM only applied the wheel lock sequence test to non-ABS vehicles, a vehicle with rear wheel only ABS should also be permitted to demonstrate brake balance by the wheel lock sequence test. They stated that the use of the wheel lock sequence test is unrelated to whether the vehicle is equipped with ABS and should be allowed for either design as an alternative to the torque wheel test.

After reviewing the comments, NHTSA has decided that only vehicles without any ABS should be required to run the wheel lock sequence test. The agency notes that differentiating between all-wheel and rear-wheel ABS as it relates to brake balance is not appropriate since in either case rear wheel lockup will not occur if the ABS is operational.

c. Torque Wheel Test. Under the 1991 SNPRM (Notice 5), a vehicle that failed any single test run of the wheel lock sequence test would be subjected to the torque wheel⁸ test to directly measure braking forces under a wide range of deceleration conditions and provide data needed to generate detailed adhesion utilization calculations. Under the proposal, to pass the torque wheel test, a vehicle would need to demonstrate that the plots of its adhesion utilization performance fell within a specified range. Section S7.4.3 sets forth the test conditions for the torque wheel procedure, including initial brake temperature, test speed, pedal force, cooling, number of test runs, test surface, and the data to be recorded.

NHTSA tentatively concluded that the torque wheel test represented an objective and repeatable method for gathering data for the construction of adhesion utilization curves. The agency noted that the torque wheel procedure requires more expensive test equipment and more time to administer than the wheel lock sequence test.

After reviewing the available information, NHTSA has decided to modify the section on torque wheel testing in S7.4 to exclude from testing any car equipped with ABS. The agency has determined that adhesion utilization testing is only relevant for brake balance in the event of lock up, which will either not occur, or occur for negligible amounts of time, on wheels controlled by ABS. Assuming the ABS is operating, this is true for vehicles in which all wheels are directly controlled by ABS, or on rear wheel-only ABS vehicles. In rear wheel-only ABS vehicles, the front wheels would always lock before the rear wheels, which would not lock at all, or lock for negligible amounts of time. Accordingly, the number of cars that will have to undergo adhesion utilization testing will drop to a small percentage of the overall fleet as ABS

becomes more prevalent over the next few years.⁹

GM, Ford, MVMA, and Chrysler requested that S7.4.3 be changed to require stops from 50 km/h at both GVWR and LLVW, in addition to the proposal for stops from 100 km/h. They stated that the additional test runs would increase the database's statistical accuracy and provide stopping data at the speed at which the wheel lock sequence test is conducted. They state that specifying an additional test speed will reduce the standard error in the estimate by 30 percent. In addition, GM stated that by specifying two test speeds, a manufacturer would no longer be able to design speed sensitive brake systems specifically designed to handle stops from 100 km/h. Similarly, Ford commented that alternating between the test speeds would avoid speed conditioning of the brakes.

After reviewing the comments and other available information, NHTSA has decided to modify S7.4.3 to require five stops from 100 km/h, and five stops from 50 km/h, at each of the test weights, LLVW and GVW, for a total of 20 stops. The agency agrees with the commenters that stops from both speeds will prevent speed conditioning and ensure that manufacturers design brakes that will be effective over a wide range of initial speeds. NHTSA has decided to increase the maximum pedal force rate to 200 N/second (45.0 lbs./sec.) for the stops from 50 km/h in order to achieve sufficient deceleration levels.

Ford stated that the paired torque and force values generated for S7.4.4 may not be uniformly distributed when plotted against each other, a situation that may affect the overall outcome. Ford stated that data point distribution will not be uniform if the pedal force and the vehicle deceleration are not changing linearly. It recommended using a linear regression analysis after dividing the input force into several increments and averaging all data points within the respective increments to yield a single average value for that increment.

NHTSA has determined that the modification recommended by Ford is not necessary. The agency believes that there will be no "constant pedal force" increments at all, if the rates of pedal force application are held within the limits prescribed in S7.4.3(c). The agency notes that in evaluating this phenomenon in the context of worst case scenarios, VRTC determined that

⁸Torque wheels are strain gauge instrumented devices that fit between the brake rotor or drum and the wheel assembly, and which directly measure the reaction torque that is developed by the friction between the tire and road surface during braking.

⁹The agency estimates that by model year 1999, when FMVSS No. 135 will come into full force, approximately 85–90 percent of passenger cars will be ABS-equipped.