AASHTO

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June 2022 ERRATA for *Manual for Assessing Safety Hardware,* 2nd Edition (MASH-2-UL)

June 2022

Dear Customer:

AASHTO has issued a fourth erratum, which includes technical revisions, for the *Manual for Assessing Safety Hardware,* 2nd Edition (MASH-2). Attached please find the full errata listing of changes that shows when each set of changes were made. Those changes detailed in the table are displayed in **bold** on those pages within the text.

Please feel free to download this listing from the AASHTO online Store at:
http://downloads.transportation.org/MASH-2-UL-Errata.pdf

AASHTO staff sincerely apologizes for any inconvenience.

List of Errata for AASHTO *Manual for Assessing Safety Hardware,* 2nd Edition (MASH-2-UL)

Original Page	Section	Existing Text	Corrected Text
June 2020 Errata			
16	Table 2-2B	Title: Recommended Test Matrices for Longitudinal Barriers	Title: Recommended TL-3 Test Matrix for Single Cable Median Barrier Designed for Placement Anywhere in 4H:1V V-Ditch
16–19	Tables 2B-2E		In table titles, change "Median Barrier" to "Cable Median Barrier"
19	Table 2-2E. Test 3-13. Barrier Location.	9 ft from Front SBP	4 ft from Front SBP
19	Table 2-2E. Test 3-14 Barrier Location.	9 ft from Front SBP	4 ft from Front SBP
21–22	Fig 2-2A and 2-2B		Add Test 17 (1500A) [See Note 3] to first cross section on each; remove heading at top of figure.
24	2.2.1.2 Test 17	For cable barriers installed on mostly level terrain or adjacent to steep roadside slopes (i.e., steeper than 3H:1V), Test 17 is recommended for evaluating the risk for passenger vehicles to penetrate between cables depending on barrier configuration (i.e., cable spacing, cable heights, etc.).	For cable barriers installed on mostly level terrain or adjacent to steep roadside slopes (i.e., steeper than 3H:1V), Test 17 evaluates the risk for passenger vehicles to penetrate between cables depending on barrier configuration (i.e., cable spacing, cable heights, etc.).
27	Table 2-3 for Non-redirective Crash Cushions Impact Tolerances Acc. Range for Tests:	1-40: ≥ 26 (35.6) 1-41: ≥ 54 (73.5) 1-42: ≥ 116 (158.0) 1-43: ≥ 26 (35.6) 1-44: ≥ 54 (73.5) 1-45: ≥ 98 (133.0)	1-40: ≥ 72 (98) 1-41: ≥ 149 (201) 1-42: ≥ 72 (98) 1-43: ≥ 149 (201) 1-44: ≥ 149 (201) 1-45: ≥ 98 (133)
28	Table 2-3 for Non-redirective Crash Cushions Impact Tolerances Acc. Range for Tests:	2-40: ≥ 51 (69.7) 2-41: ≥ 106 (144.0) 2-42: ≥ 228 (309.0) 2-43: ≥ 51 (69.7) 2-44: ≥ 106 (144.0) 2-45: ≥ 192 (261.0)	2-40: ≥ 141 (191) 2-41: ≥ 291 (395) 2-42: ≥ 141 (191) 2-43: ≥ 291 (395) 2-44: ≥ 291 (395) 2-45: ≥ 192 (261)
29	Table 2-3 for Non-redirective Crash Cushions Impact Tolerances Acc. Range for Tests:	3-40: ≥ 105 (142) 3-41: ≥ 216 (294) 3-42: ≥ 465 (631) 3-43: ≥ 105 (142) 3-44: ≥ 216 (294) 3-45: ≥ 392 (532)	3-40: ≥ 288 (390) 3-41: ≥ 594 (806) 3-42: ≥ 288 (390) 3-43: ≥ 594 (806) 3-44: ≥ 594 (806) 3-45: ≥ 393 (532)

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Original Page	Section	Existing Text	Corrected Text
35	Test 44	Test 44 is designed to evaluate the ability of a non-redirective crash cushion to safely stop a large passenger vehicle in a side impact.	Test 44 is designed to evaluate the ability of a non-redirective crash cushion to safely stop a large passenger vehicle in an impact along the side of the device.
37	Table 2-4. for Test Level 1, Test 1-50, Kinetic Energy Tolerance	≥ 72 (97)	≥ 72 (98)
39	Test 54	**TEST 54 (Optional)** Test 54 is designed to evaluate the staging of energy absorbers in a TMA for impacts involving mid-size automobiles. It is desirable that TMAs provide acceptable levels of protection for all passenger vehicles. There is some concern that existing designs are finely tuned to minimize the TMA length while meeting the requirements of the small passenger car and heavy pickup truck tests, and designers do not consider occupant risk parameters for mid-sized car impacts. On the other hand, if existing designs must be lengthened to meet the requirements of this new test, there is concern that costs and operational problems may increase greatly and that durability will be diminished. Therefore, Test 54 is considered optional. However, manufacturers and user agencies are encouraged to develop and implement TMAs that can safely accommodate mid-sized vehicles. As presented previously in the description of Tests 38 and 45, this test can be waived with an analysis of the accelerometer data from Test 51 that indicates proper attenuator staging.	**TEST 54** Test 54 is designed to evaluate the staging of energy absorbers in a TMA for impacts involving mid-size automobiles. It is desirable that TMAs provide acceptable levels of protection for all passenger vehicles. There is some concern that existing designs are finely tuned to minimize the TMA length while meeting the requirements of the small passenger car and heavy pickup truck tests, and designers do not consider occupant risk parameters for mid-sized car impacts. On the other hand, if existing designs must be lengthened to meet the requirements of this new test, there is concern that costs and operational problems may increase greatly and that durability will be diminished. Manufacturers and user agencies are encouraged to develop and implement TMAs that can safely accommodate mid-sized vehicles. Test 54 will be necessary unless, as presented previously in the description of Tests 38 and 45, with an analysis for the occupant risk parameters through the accelerometer data from Test 51 indicates proper attenuator staging is obtained. Test 54 should be conducted with the heaviest support vehicle mass or a blocked support vehicle similar to tests 50, 51, and 52, in order to maximize occupant risk for the mid-size sedan occupants.

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Original Page	Section	Existing Text	Corrected Text
42	Table 2-5. Acceptable KE Range	1-61: ≥ 72 (97) 1-71: ≥ 72 (97) 1-80: ≥ 94 (115) 1-90: ≥ 72 (97) 2-80: ≥ 94 (115) 3-80: ≥ 94 (115) 3-90: ≥ 141 (191) 3-91: ≥ 291 (395)	1-61: ≥ 72 (98) 1-71: ≥ 72 (98) 1-80: ≥ 72 (98) 1-90: ≥ 72 (98) 2-80: ≥ 72 (98) 3-80: ≥ 72 (98) 3-90: ≥ 288 (390) 3-91: ≥ 594 (806)
102	Table 5-1A. Applicable tests for Evaluation Criteria A.	10, 11, 12, 20, 21, 22, 30[a],31[a],32[a],33[a], 34[a], 35, 36, 37[a], 38[a]	10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 30[a], 31[a], 32[a], 33[a], 34[a], 35, 36, 37[a], 38[a]
103	Table 5-1B. Applicable tests for Evaluation Criteria H-Longitudinal and Lateral	10, 11, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 50, 51, 52, 53, 80, 81, 82, 90, 91	10, 11, 13, 14, 15, 16, 17, 18, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 50, 51, 52, 53, 80, 81, 82, 90, 91
103	Table 5-1B. Applicable tests for Evaluation Criteria I-Longitudinal and Lateral	10, 11, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 50, 51, 52, 53, 54, 60, 61, 62, 70, 71, 72, 80, 81, 90, 91	10, 11, 13, 14, 15, 16, 17, 18, 20, 21, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 50, 51, 52, 53, 54, 60, 61, 62, 70, 71, 72, 80, 81, 82, 90, 91
104	Table 5-1C. Applicable Tests for Evaluation Criteria N	30[b], 31[b], 32[b], 33[b], 34[b], 37[b], 38[b], 40, 41, 42, 43, 44, 45, 60, 61, 70, 71, 72, 80, 81, 82, 90, 91	30[b], 31[b], 32[b], 33[b], 34[b], 37[b], 38[b], 40, 41, 42, 43, 44, 45, 60, 61, 62, 70, 71, 72, 80, 81, 82, 90, 91
106	5.2.2 Occupant Risk. Last paragraph on Page 106 ("It is essential…")	Paragraph ends with "… permit direct comparisons of before- and after-test conditions."	To the end of the paragraph, add: "The procedure given in Appendix E may be used to document the three-dimensional coordinates of the vehicle interior, prior to and after the test. By comparing the pre- and post-test interior coordinates, the extent of occupant compartment deformation can be calculated."
122–276	**General Note:** Due to the addition of larger sections of text, the pagination has changed from this point of the book and beyond.		

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Original Page	Section	Existing Text	Corrected Text
135	A2.2.1 Longitudinal Barriers.	Text is missing after the first paragraph.	After the first paragraph, insert new paragraph: Note that target IS values for Test Levels 1 through 4 have been increased significantly. The increased severity will produce higher barrier impact loadings. It is therefore recommended that barrier design loads presented in AASHTO's Standard Specifications for Highway Bridges (4) be adjusted upward to reflect the new impact conditions.
135–139	A2.2.1 Longitudinal Barriers.	Text is missing.	Add text in section labeled A below.
144–145	A2.3 Impact Point for Redirective Devices.	Text is missing.	Add text in section labeled B below.
165	A5.2.2 Bullet for Windshield.	Text is missing.	Add text in section labeled C below.
166	A5.2.2 Bullet for Window.	Text is missing.	Add text in section labeled D below.
167	A5.2.2 Last paragraph.	Text edits are missing.	Add text in section labeled E below.
170	A5.2.3 Post-Impact Vehicular Response.	New text missing	Add text in section labeled F below.
176 and 180	Appendix B Text and Figures B.2 and B.4 depict a 2-ft diameter hole for use with post placement.	Text and figures depict a 2-ft diameter hole for use with post placement.	Text and figures should show a 3-ft diameter hole for use with post placement.
224 *(Cont'd. on next page)*	D1.8 Bogie Test. Second paragraph	Bogie vehicles may be used to simulate impacts with breakaway structures, work-zone traffic control devices, longitudinal barriers, or components of such systems. As discussed in Section 4.2.2, bogie vehicles must be revalidated periodically to ensure that the devices are representative of modern vehicles.	Replace paragraph entirely with: As discussed in Section 4.2.2, bogie vehicles must be revalidated periodically if the devices are to be representative of modern vehicles. Existing bogies have been designed to replicate vehicular crush characteristics and inertial properties of vehicles more than 25 years old. These bogie vehicles have been shown to be capable of simulating impacts with breakaway structures. However, significant improvements to the

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Original Page	Section	Existing Text	Corrected Text
224 (*Cont'd.*)	D1.8 Bogie Test. Second paragraph		vehicle crush and suspension models must be made before existing bogies can be expected to replicate impacts with other safety features such as longitudinal barriers.
251	Appendix H.	Text is missing.	Add text in section labeled G below.
254	Appendix H.	Text is missing.	Add text in section labeled H below.
July 2020 Errata			
xiii	Table 2-2B through 2E listings	These tables have table captions that read: "…Median Barrier…"	These table captions should read …"Cable Median Barrier…"
37	Table 2-4	[d] Test is optional.	Footnote [d] removed from Tests 1-54, 2-54, and 3-54, as well as from the footnote list.
September 2021 Errata			
86	Table 4-2, Dimensions, in. (mm). Overall Length (max) for 36000V (Tractor/Van Trailer). Combination	780 (19,850)	816 (20,726)
June 2022 Errata			
42	Table 2-5, Acceptable KE Range	1-60: ≤34 (41) 1-70: ≤34 (41) 2-60: ≤34 (41) 2-70: ≤34 (41) 3-60: ≤34 (41) 3-70: ≤34 (41)	1-60: ≤34 (46) 1-70: ≤34 (46) 2-60: ≤34 (46) 2-70: ≤34 (46) 3-60: ≤34 (46) 3-70: ≤34 (46)

A. Text to add to Appendix A, A2.2.1. Insert after the third paragraph of this section ("While it is preferable…"):

In 2012, researchers at the Midwest Roadside Safety Facility (MwRSF) proposed an updated series of crash tests for evaluating cable median barriers placed in symmetric V-ditches (150). Using LS-DYNA simulations, critical bumper trajectories were plotted for five different vehicle models encroaching across both 4H:1V and 6H:1V V-ditches with widths varying from 24 to 46 ft. The maximum and minimum simulated bumper height trajectories were used to determine critical locations for barrier override or underride as well as an increased risk for vehicle instability, barrier penetration, or excessive deformation of the occupant compartment. For this effort, simulated trajectories of MASH vehicles (1100C, 1500A, and 2270P) and NCHRP 350 vehicles (820C and

2000P) were included to obtain a more complete understanding of the risks associated with cable barrier impacts involving passenger vehicles.

Although the ability to validate the vehicle models was limited, the simulated vehicle behaviors were believed to be generally representative of vehicles traversing V-ditches. It should be noted that the simulation results were based on the assumption that the ditch surface was uniform and rigid. In real-world applications, varying soil conditions and surface irregularities could affect vehicle kinematics and alter vehicle trajectories.

TESTS 10 and 11

Historically, Tests 10 and 11 have primarily been used to evaluate the impact performance of longitudinal barriers (e.g., W-beam guardrails and cable barriers), installed on flat, level terrain. However, cable barrier systems are typically installed in median ditches. For these applications on slopes, the cable barrier systems are typically taller than those systems that were historically crash tested and evaluated on level terrain but subsequently installed on slopes as steep as 6H:1V. Higher longitudinal cable elements may pose an increased risk to the integrity of the vehicle's occupant compartment (e.g., A-pillar, windshield, and roof). As such, Tests 10 and 11 are designed to investigate the safety performance of cable barrier systems that are configured for ditch applications but may also include use on mostly flat, level terrain. Further, Tests 10 and 11 would also be used to evaluate cable barrier systems intended for shielding roadside slopes steeper than 3H:1V when installed in front of or at the slope break point.

TEST 13

Test 13 may also provide a critical test for evaluating a cable barrier's working width due to: (1) the likelihood for vehicle contact higher on the barrier system; (2) the potential for the top cable to more easily release from posts; (3) the propensity for fewer cables to be active in capturing the airborne vehicle; and (4) an increased impact energy due to the elevation change at barrier contact.

Previously, both 30-ft and 46-ft wide V-ditches were considered for Test 13. From one perspective, a 46-ft wide ditch was believed to provide greater propensity for override and/or vehicle instability if the vehicle were allowed greater vertical drop as well as increased pitch and roll motion prior to redirecting or reaching the bottom of the backslope. Another perspective was that a 30-ft wide ditch provided greater propensity for vehicular instability when wheel and/or bumper contact with the backslope occurred more quickly and abruptly during the redirection process. It is noted that the identification of the critical ditch width would require comparisons between numerous cable barrier crash tests in both ditch configurations. In the absence of this extensive testing data, and in an effort to simplify the test matrices, a 46-ft wide V-ditch was recommended for Test 13 in 4H:1V median sections, while a 30-ft wide V-ditch was recommended for Test 13 in 6H:1V median sections.

TEST 15

For depressed medians, the greatest risk of barrier underride occurs when an airborne vehicle contacts the back slope and fully compresses the vehicle's front suspension, resulting in the lowest front-end height above the ditch surface immediately prior to barrier contact. Previously, both the 1100C small car and 1500A mid-size sedan were considered critical for evaluating the propensity to underride cable barriers installed in depressed medians. The 1500A vehicle is heavier than the 1100C vehicle and achieved a lower minimum bumper height in the simulated vehicle encroachments. Thus, it was argued that a 1500A crash test may provide a higher risk for barrier underride. However, the low-profile, front-end geometry of the 1100C vehicles may also lead to vehicle underride. Additionally, the 1100C passenger car is typically characterized as having a weaker A-pillar compared to the 1500A mid-size passenger sedan. Further, the lighter 1100C vehicle may likely have increased concerns for excessive occupant ridedown accelerations and/or occupant impact velocities compared to the 1500A vehicle. Consequently, due to its low-profile, front-end geometry, weaker A-pillar structure, and lower mass, the 1100C small passenger car was selected as the design vehicle for Test 15 to evaluate barrier underride within the ditch.

For cable barriers installed 0 to 4 ft away from the SBP of a 4H:1V V-ditch, simulation results for a narrow, 24-ft wide ditch indicated that the location with the maximum potential for underride with an 1100C vehicle occurred approximately 6 ft away from the back SBP. Hence, the critical underride test condition would likely correspond with barrier placement approximately 4 ft away from the back SBP of a slightly narrower, 22-ft wide ditch. When deemed necessary and for barrier placement 0 to 4 ft away from the SBP, Test 15 could be conducted in a 4H:1V V-ditch with a barrier placed: (1) 4 ft away from the back SBP of a 22-ft wide V-ditch; (2) 6 ft away from the back SBP of a 24-ft wide V-ditch; or (3) conservatively 4 ft away from the ditch bottom and up the back slope of 46-ft wide ditch. In order to simplify the test matrices, a 46-ft wide V-ditch was recommended for Test 15 when evaluating cable barrier placed in 4H:1V median sections.

For cable barriers installed 0 to 4 ft away from the SBP of a 6H:1V V-ditch, simulation results for a narrow, 24-ft wide ditch indicated that the location with the maximum potential for underride with a 1100C vehicle occurred approximately 8 ft away from the back SBP. Hence, the critical underride test condition would likely correspond with barrier placement approximately 4 ft away from the back SBP of a narrower, 20-ft wide ditch. When deemed necessary and for barrier placement 0 to 4 ft away from the SBP, Test 15 could be conducted in a 6H:1V V-ditch with a barrier placed: (1) 4 ft away from the back SBP of a 20-ft wide V-ditch; (2) 8 ft away from the back SBP of a 24-ft wide V-ditch; or (3) conservatively 4 ft away from the ditch bottom and up the back slope of 30-ft wide ditch. In order to simplify the test matrices, a 30-ft wide V-ditch was recommended for Test 15 when evaluating cable barriers placed in 6H:1V median sections.

TEST 16

Prior crash testing has demonstrated that two critical conditions can arise when a small passenger car lands in the ditch bottom and traverses up the back slope prior to barrier contact. After vehicle contact with the slope, the front tires may potentially steer up the back slope and increase the heading angle and/or induce a yaw velocity counter to the desired redirection. This phenomenon, which has been observed in previous 820C crash testing under NCHRP Report No. 350, can result in an increased impact severity and greater propensity for occupant compartment deformation and vehicular instability.

Alternatively, small passenger vehicles may encounter significant rebound and become airborne after landing on the ditch back slope prior to contact with the barrier system, thus resulting in greater propensity for barrier override and vehicular instability. Barrier override may occur after the airborne vehicle contacts the ditch surface and rebounds up the back slope, once again becoming airborne. Results from a full-scale crash test demonstrated that an 1100C small passenger vehicle can rebound off of the back slope and launch into a cable barrier that is placed 4 ft away from the back SBP of a 30-ft wide 4H:1V V ditch (157). In this test, the vehicle was captured by the top cable positioned at a height of 45 in. above grade. From the simulation effort (150), the 1100C bumper trajectory was lower than observed in the noted crash test (157). However, the simulation results indicated that the greatest rebound off the back slope for the 1100C vehicle occurred in a 30-ft wide 4H:1V V-ditch. Conversely, the simulations indicated that the greatest rebound off of the back slope for the 1100C vehicle occurred in a 46-ft wide 6H:1V V-ditch.

In order to simplify the test matrices and consider all critical behaviors, a 46-ft wide V-ditch was recommended for Test 16 in 4H:1V median sections, while a 30-ft wide V-ditch was recommended for Test 16 in 6H:1V median sections.

TEST 17

For Test 17, a 1500A mid-size sedan was selected instead of an 1100C small car due to its larger inertia combined with a relatively-narrow front profile. Additionally, a recent cable barrier accident study had shown that mid-size sedans were the most common vehicles involved in cable barrier penetrations (158, 159).

As cable barrier systems are configured for use in depressed medians, a greater number of cables may be necessary for containing and redirecting the range of passenger vehicles. Compared to configurations designed for use on flat, level ground, cable barriers designed for use in median ditches typically require cable elements placed higher than normal on support posts to prevent override, and lower than normal on posts to prevent underride. As the top and bottom cables are raised and lowered to mitigate concerns for override and underride, respectively, the vertical spacing between cables will increase if the number of cables is held constant. An increased vertical spacing between cables may increase the propensity for vehicle penetration between the cables. Thus, it is necessary to evaluate the risk for vehicle penetration between vertically adjacent cables. For this test, the critical impact point is midspan between adjacent posts rather than 12 in. upstream from a barrier post.

The risk for vehicle penetration is dependent on the specific design details of a particular cable barrier system, including the position of adjacent cables relative to the front bumper of the 1500A vehicle, vertical cable position and width of the largest vertical opening between adjacent cables, cable-to-post attachment release mechanisms, and the vehicle's projectile motion beyond the slope break point. The testing agency should identify the critical barrier placement that maximizes the propensity for the vehicle's front end to penetrate between adjacent cables. Depending on the barrier configuration, a cable barrier installed on level terrain but at the front SBP may provide a critical test condition for evaluating the risk of penetration. However, if the largest vertical cable gap occurs higher on the posts or a cable is aligned closer to the center of the bumper, it may be necessary to laterally shift the barrier down the foreslope to obtain the critical impact condition. A vehicle's projectile motion for a critical bumper point beyond the front SBP may aid in selecting a lateral barrier offset that results in a critical impact height.

Similar to Tests 10 and 11, Test 17 would also be used to evaluate cable barrier systems intended for shielding roadside slopes steeper than 3H:1V when installed in front of or at the slope break point.

TEST 18

As previously noted, two critical vehicle behaviors were found to occur as small passenger vehicles contact the ditch surface and traverse up the back slope prior to barrier contact. Likewise, it is reasonable to expect similar behaviors for other vehicle types, such as pickup trucks and mid-size passenger sedans. Computer simulations and limited crash testing involving pickup trucks impacting median ditches revealed similar tendencies to rebound and become airborne after landing on the back slope prior to contact with the cable barrier, thus resulting in greater propensity for barrier override and vehicular instability (150, 151, 156, 160). Simulated bumper trajectories demonstrated that a 2270P vehicle would reach greater heights above the ditch surface than an 1100C vehicle after rebounding off of the back slope. The difference in the maximum height of the 2270P bumper trajectories for 30-ft, 38-ft, and 46-ft wide 4H:1V V-ditches was negligible. However, these simulations indicated that the greatest rebound of the 2270P vehicle off of the back slope occurred in a 46-ft wide 4H:1V V-ditch and at a location 8 ft away from the back SBP. For a 30-ft wide 4H:1V V-ditch, the greatest rebound off of the back slope for a 2270P vehicle occurred approximately at the back SBP. For 6H:1V V-ditches, the maximum bumper height was very close for both 30 and 46 ft wide sections, although the greatest rebound off of the back slope for a 2270P vehicle occurred in a 46-ft wide section and 6 ft away from the back SBP. For a 30-ft wide 6H:1V V-ditch, the greatest rebound of the 2270P vehicle off of the back slope occurred approximately at the back SBP.

Light trucks and SUVs may also acquire an increased heading angle prior due to interaction with the back slope prior to contact with the barrier, thus leading to a greater propensity for vehicular instability or cables passing over the engine hood and contacting the windshield. In order to simplify the test matrices and consider all critical behaviors, a 46-ft wide V-ditch was recommended for test 18 in 4H:1V median sections, while a 30-ft wide V-ditch was recommended for test 18 in 6H:1V median sections.

B. Text to add to Appendix A, A2.3. Insert after the second paragraph of this section ("NCHRP report 350 (129) produced…"):

For flexible cable barriers intended for use in median ditches, four out of the eight full-scale crash tests in the test matrices utilize an 1100C small car passenger vehicle. In general, narrow post spacing is generally deemed more critical for small car tests than a wide post spacing. First, there is greater risk for excessive occupant compartment deformation to the roof, windshield, and A-pillar due to increased cable loading imparted to the vehicle. Second, there is an increased risk for vehicular instability due to contact with a greater number of support posts. Thus, the narrowest post spacing was selected for use in Tests 10, 14, and 16. If underride is a primary concern, then the widest post spacing would provide the greatest risk for small car passenger vehicles to penetrate under the bottom cable and push it upward. Thus, the widest post spacing was selected for use in Test 3-15.

Only one mid-size vehicle (1500A) is included in the test matrices for evaluating flexible cable barriers installed in median ditches. Test 17 is intended to investigate the potential for a heavier, sharp-nosed, passenger vehicle to penetrate between adjacent vertically-spaced cables as well as to evaluate the propensity for excessive occupant compartment damage. The widest post spacing was deemed most critical due to an increased propensity for adjacent cables to separate and allow vehicle penetration.

Finally, three out of the eight full-scale crash tests in the test matrices for evaluating flexible cable barriers installed in median ditches utilize a 2270P light-truck passenger vehicle. When a range of post spacing is desired, Test 11 is conducted on level terrain at both the widest and narrowest post spacings in order to define the system's working width at the two limits of lateral barrier stiffness. For Test 13 on the front slope and Test 18 on the back slope, arguments can be made that both a narrow spacing or wide spacing could be more critical for evaluating the potential for vehicle override. The narrowest post spacing provides an increased propensity for vehicle instability due to vehicle interaction with additional support posts and/or higher lateral cable resistance imparted to the side of the vehicle that could result in tripping. On the other hand, the widest post spacing may provide increased opportunity for vehicle override due to the fact that the top cables could be more easily pushed down. Thus, the remaining two 2270P tests were used to evaluate override at both the widest and narrowest post spacing. Test 13 utilizes the narrowest post spacing as the vehicle would be airborne above the front slope when contacting the upper region of the cable barrier, thus creating a critical condition for evaluating stability, rollover, and override. For light-truck vehicles traversing up the back slope, a more severe impact condition may be achieved as a result of the vehicles interaction with the back slope prior to contacting the cable barrier, thus increasing concerns for override or penetration. Thus, Test 18 was selected to utilize the widest post spacing.

In general, most flexible, cable median barriers may be impacted on either side of the system. Consequently, guidance has been provided for evaluating cable median barriers in an orientation that places its primary capture cable in the most critical position for each test. Using this methodology, a cable median barrier system could be installed in the field at either 0 degrees or 180 degrees, either at 0 to 4 ft offset from the SBP or anywhere within the median ditch. However, it is possible that some cable median barriers may be prescribed to be installed using only one orientation (i.e., 0 degrees but not 180 degrees or vice versa) within 0 to 4 ft offset from the SBP. Under those circumstances, there may be justification for evaluating a cable median barrier with a vehicular impact only on the front side for Tests 13, 14, and 17 and only on the back side for Tests 15, 16, and 18. For Tests 10 and 11, the cable median system is evaluated on level terrain and may be struck on either side of the system. Thus, these tests should always be performed with the primary capture cable placed in its most critical position (i.e., back side of critical post).

C. Text to add to Appendix A, A5.2.2. Under Occupant Compartment Deformation and Intrusion, the bullet for Windshield should read (changes highlighted):

- **Windshield**—No tear of plastic liner and maximum deformation of 3 in. (76 mm). A much lower limiting extent of deformation was selected for the windshield area; since, an occupant, particularly an unbelted occupant, would move forward toward the windshield. Thus, deformation of the windshield would increase the potential of the occupant impacting the windshield and could lead to more severe injuries. Also, tearing of the plastic liner could lead to penetration of the occupant compartment and thus is not permitted. Note that a tear in the windshield's plastic liner is only precluded when there is a potential for a test article component to penetrate into the vehicle. Tearing of the plastic liner produced when a continuous test article contacts the windshield support structure may be acceptable. For example, a continuous, flexible cable element may contact and plastically deform the A-pillar of an impacting vehicle within acceptable limits and result in minor tearing of the windshield's plastic liner. Although tearing may occur, there may be no concern for a continuous cable element to penetrate into the occupant compartment. Under this scenario, minor tearing of plastic liner is considered acceptable.

D. Text to add to Appendix A, A5.2.2. Under Occupant Compartment Deformation and Intrusion, the bullet for Window should read (changes highlighted):

- **Window**—No shattering of a side window resulting from direct contact with a structural member of the test article, except for special situations discussed below. In cases where the windows are laminated, the guidelines for windshields will apply. It was observed that the occupants' head would typically strike the side window in redirectional impacts with semi-rigid and rigid barriers. Thus, if the side window was shattered from direct contact with a structural member of the test article, it is logical to assume that the occupant's head could also strike the structural member and result in serious injuries. However, longitudinal barriers can vary significantly in terms of lateral stiffness and strength, thus altering the safety risks posed to vehicle occupants. Passenger vehicle impacts into flexible cable barriers may allow a continuous cable element to contact a side window and cause it to fracture. Flexible cable elements may also contact and plastically deform a vehicle's A-pillar and/or B-pillar within acceptable limits. Because of the low vehicle decelerations associated with impacts into flexible barriers, lateral movement of the occupant is limited and contact with the occupant's head is unlikely. In such instances, it is reasonable to allow side window fracture to occur as long as several conditions are met: (1) the A- or B-pillars should not be completely severed, (2) the maximum resultant deformation to any support member does not exceed 5 in. (127 mm), and (3) the maximum lateral deformation to any support member does not exceed 3 in. (76 mm).

E. Text to add to Appendix A, A5.2.2. Last paragraph after bullets, before Flail-Space Model header (changes highlighted):

It should be emphasized that any occupant compartment damage should be carefully documented in the form of photographs and measurements, particularly for penetrations and area(s) where the maximum extent(s) are exceeded. The same applies for any damage to, or rupture of, the interior and exterior floorboard and rear trunk, the fuel tank, oil pan, or other features that might serve as a surrogate of a fuel tank.

F. Text to add to Appendix A, A5.2.3. After second paragraph ("For redirectional performance test…"), (changes highlighted):

Under NCHRP Report 350 (119), there are four evaluation criteria under post-impact vehicular trajectory:

1. After collision it is preferable that the vehicle's trajectory not intrude into adjacent traffic lanes.
2. The occupant impact velocity in the longitudinal direction should not exceed 12 m/s and the occupant ridedown acceleration in the longitudinal direction.
3. The exit angle from the test article preferably should be less than 60 percent of test impact angle, measured at time of vehicle loss of contact with test device.
4. Vehicle trajectory behind the test article is acceptable.

Only Criterion N, which lists the tests for which vehicle trajectory behind the test article is acceptable, is retained in this document. Criteria K and M were excluded from this document since they are considered preferable, but not mandatory. An effort was made in this document to include only mandatory evaluation criteria that can be assessed in an objective manner. All safety feature crash tests previously subject to criterion L are now required to meet criteria H and I. Thus, Criterion L was also eliminated from this document.

For redirective devices, it is preferable that the vehicle be smoothly redirected. Under NCHRP Report 350, the assessment is based on the requirement that the exit angle should not exceed 60 percent of the impact angle. In the current document, the "exit box" criterion was adopted from the

CEN standards. As shown in Figure 5-1, the exit box is defined by the initial traffic face of the barrier and a line parallel to the initial traffic face of the barrier, at a distance A plus the width of the vehicle plus 16 percent of the length of the vehicle, starting at the final intersection (break) of the wheel track with the initial traffic face of the barrier for a distance of B. It is preferable for the vehicle to exit within the "exit box," i.e., all wheel tracks of the vehicle should not cross the parallel line within the distance B. As a point of reference, the "exit box" is equivalent to a maximum exit angle of 12.4 degrees.

G. Appendix H. Last paragraph before Table H-1 should read (new text highlighted):

In recognition of the rapid increase in vehicle weights over the last 15 years and the expectation that the recent rise in gasoline prices may begin to push vehicle weights down, the 90th percentile vehicle weight was selected as the appropriate size for the light truck test vehicle. Initially, a $^{3}/_{4}$-ton, two-wheel drive, regular cab pickup truck, such as the Chevrolet Silverado 2500, was selected as the candidate test vehicle. This was the same vehicle recommended by NCHRP Report 350 (119), and it had the correct curb weight. By retaining the same test vehicle used in the prior document and merely increasing the target vehicle weight, the new performance evaluation guidelines would maintain the maximum possible connection with the prior procedures. In this situation, testing agencies' and hardware designers' experience with the Report 350 vehicle would carry forward to the new procedures.

H. Appendix H. Insert new paragraph after Table H-2 (before paragraph starting with "Vehicles with curb weights…"):

However, commonly available $^{3}/_{4}$-ton pickup trucks were found to have a center-of-gravity (c. g.) height significantly below that of the large SUV class that the light truck test vehicle is supposed to represent. As shown in Table H-3, most large SUVs have c. g. heights in the range of 28 in. (710 mm) to 29.5 in. (750 mm) while those for $^{3}/_{4}$-ton, regular cab pickup trucks are closer to 27 in. (685 mm). In order to assure that the c. g. heights of the test vehicles are more closely matched with those of large SUVs, a $^{1}/_{2}$-ton, two-wheel drive, four-door pickup truck was chosen to replace the current test vehicle.