Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject: Action: Identifying Acceptable Highway Safety Features

Date: JUL 25 1997

From: For: Director, Office of Engineering

Reply to Attn. of: HNG-14

To: Regional Administrators
Federal Lands Highway Program Administrator
Division Administrators
Federal Lands Highway Division Engineers

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required the Secretary of Transportation to institute measures to enhance the crashworthy performance of roadside features to accommodate vans, mini-vans, pickup trucks, and 4-wheel drive vehicles. In recognition of this requirement, the 1993 National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* (NCHRP Report 350), contains guidance for testing highway features with pickup trucks to assess the safety performance of those features. The Federal Highway Administration (FHWA) believes the pickup truck is an acceptable surrogate for the other vehicles cited in the ISTEA. Through a formal rulemaking process that culminated in a final rule in a notice in Volume 58, No. 135, of the Federal Register, dated July 16, 1993, the FHWA added Report 350 at paragraph 625.5(a)(13) of Title 23, Code of Federal Regulations (23 CFR). Since that time the "Guides and references" section of 23 CFR, Part 625, under which the NCHRP Report 350 was cited, has been removed. The NCHRP Report 350 is now cited in Section 16, Paragraph (a)(12) of the Non-Regulatory Supplement to the Federal-aid Policy Guide, Subchapter G, Part 625 (NS 23CFR 625). To further promulgate application of the guidelines in the NCHRP Report 350 a memorandum from the Office of Engineering, "Information: Procedures for Determining Acceptability of Highway Features," dated November 12, 1993, was sent to Regional Federal Highway Administrators and the Federal Lands Highway Program Administrator.

The effect of both the Federal Register notice and the November 1993 memorandum was a strong indication that, after five years from the effective date of the final rule in the notice, the FHWA would require all new installations of highway features on the National Highway System (NHS) that are covered in the NCHRP Report 350 to have been tested and found acceptable according to the guidelines in that report. Thus, the resulting nominal deadline for full compliance with the recommended guidelines in the NCHRP Report 350 was set at August 16, 1998. However, also in the Federal Register notice was a statement that "... the FHWA wants to assure all that during the scheduled transition period it will continually reassess its position."

In the spirit of that promise, an outline of the FHWA's current position follows:

- Except as modified below, all new or replacement safety features on the NHS covered by the guidelines in the NCHRP Report 350 that are included in projects advertised for bids or are included in work done by force-account or by State forces on or after October 1, 1998, are to have been tested and evaluated and found acceptable in accordance with the guidelines in the NCHRP Report 350. (The slight change from the previously implied deadline was made to take advantage of any benefit there might be in having the date coincide with the beginning of the Federal fiscal year. Citing the advertising date rather than the installation dated was done to minimize project timing problems that might lead to requiring the issuance of change orders to be in strict compliance with the cited deadline.) Note that breakaway support hardware previously found acceptable under the breakaway requirements of either the 1985 or 1994 editions of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* are acceptable under the NCHRP Report 350 guidelines.

- Exceptions:

  1. For some types of breakaway supports the FHWA will accept pendulum testing and the use of the test results to calculate an estimate of high-speed breakaway performance. The FHWA will place limits on the maximum masses and heights of acceptable breakaway luminaire supports. For additional discussion and guidance on these items see the attached "Background and Guidance on Requesting Federal Highway Administration Acceptance of Highway Safety Features" (Submission Guidelines).

  2. The testing and acceptance procedures for truck-mounted attenuators and certain work-zone devices are modified in the guidance given in the Submission Guidelines.

  3. Bridge railings tested and found acceptable under other guidelines may be acceptable for use on the NHS. See the Submission Guidelines (attached) and Mr. Horne's May 30, 1997, memorandum, "Action: Crash Testing of Bridge Railings," for additional guidance.

  4. For reasons cited in the attached Submission Guidelines, for work zone crash cushions, freestanding concrete work zone traffic barriers, and portable, usually trailer-mounted, work zone devices, such as lighting supports, flashing arrow panels, temporary traffic signals, and changeable message signs, the deadline for compliance with the guidelines in the NCHRP Report 350 is October 1, 2002.

  5. For specific small, lightweight channelizing and delineating devices the Submission Guidelines provide for self certification by the developer on the basis of documented field experience or comparison with like acceptable devices.

  6. Traffic signal supports and utility poles are exempt from the crashworthiness requirements being addressed here. Actually, breakaway utility poles are expressly

covered in the NCHRP Report 350 and guidelines for testing breakaway sign and luminaire supports could reasonably be applied to traffic signal supports. Nevertheless, because of the structural requirements for utility poles and most traffic signal supports, the technical problems with making them breakaway, and the assumed net benefit to the public from allowing them, unshielded, within the clear zone, a requirement that they be made breakaway, historically, has not been imposed on them. On the other hand, they constitute real risks for motorists and all practicable measures should be taken through their location or a reduction in their numbers to reduce their risk to motorists.
In addition, because of their low structural requirements, consideration should be given to making post-top-mounted traffic signal supports breakaway.

- The FHWA does not intend that this requirement (that new highway safety features installed on the NHS be proven crashworthy in accordance with the guidelines in the NCHRP Report 350) result in the replacement or upgrading of any existing installed features beyond what would normally occur with planned highway improvements. On the other hand, a State should have a rational, documented policy for determining when an existing non-standard feature should be upgraded.

- To aid the States and the FHWA in the evaluation of the in-service performance of the work zone and roadside features and the formulation of rational policies on the deployment and upgrading of these features, it would be highly desirable if there were inventory and accident data bases of sufficient detail, accuracy, and precision that one could use them to evaluate the field performance of specific highway feature designs. Existing or emerging videolog, GPS, GIS, data warehousing, and other technologies make this a reasonable goal. It is believed that significant steps have already been taken by some States that could lead to attainment of this goal. It is recommended that regional and division personnel working in the planning and safety areas work with their State counterparts to see what can be done to accelerate the improvement and application of these technologies and the dissemination of information on their application toward attainment of the goal.

Finally, a few words on the attached Submission Guidelines, they replace a similar document that was attached to the previously cited November 1993 memorandum. While the new document contains updated information and has been expanded to address more features, the principal reason for this new version is to better describe what must be submitted by those wishing to take advantage of the Headquarters service of passing judgement on the crashworthiness of a highway feature. These guidelines should be consulted early in the development of a qualification program for a highway safety feature. If it is likely that development tests will be used to document crashworthiness of a feature, the guidelines should be considered in setting up and conducting the development testing program for a new or revised feature.

An extra copy of this memorandum is being furnished to each Division Administrator for submission to their associated State highway agency.

Donald P. Steinke

Donald P. Steinke

Attachment

Attachment

Background and Guidance on Requesting Federal Highway Administration Acceptance of Highway Safety Features

Introduction

Highway safety features, such as breakaway sign and luminaire supports, longitudinal barriers, crash cushions, and work zone traffic control devices, must demonstrate acceptable crashworthy performance to be accepted by the Federal Highway Administration (FHWA) for use on the National Highway System (NHS) within the clear zone or, particularly for work zone devices, within the roadway. From 1981 to 1993 the FHWA reviewed roadside safety hardware that had been crash tested in accordance with the procedures in the National Cooperative Highway Research Program (NCHRP) Report 230, *Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances* (Report 230). This document was never formally recognized by the FHWA. In May 1993 a revised testing procedures document, NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* (Report 350), was published. By a final rule in Federal Register Vol. 58, No. 135, dated July 16, 1993, the FHWA formally added Report 350 to 23 CFR under the "Guides and references" section, Part 625.5(a)(13). (This "Guides and references" section has since been removed from the CFR. The Report 350 citation has been transferred to Section 16, Guides and References, paragraph (a)(12), of the Non-Regulatory Supplement to the Federal-Aid Policy Guide, Subchapter G, Part 625, Design Standards for Highways (NS 23 CFR 625).) The FHWA will require, unless otherwise indicated, that all new installations of applicable highway features included in projects on the NHS advertised for bids or installed by state forces or under force account work on or after October 1, 1998, will have been found crashworthy according to the guidelines in Report 350, except as the guidelines may be modified in the guidance that follows.

Acceptance Letters

As a service to FHWA field offices, state and local highway agencies, and industry, the FHWA's Office of Engineering reviews crash test reports and other supporting documentation and issues acceptance letters to developers of crashworthy hardware. (Note that the term "developer," as used in these guidelines refers to individuals, companies, or organizations that invent, develop, modify, manufacture, sell, or promote highway safety hardware.) The FHWA does not, with rare exceptions, conduct crash testing for developers of safety hardware. Typically, the developer must contract with a testing agency that is recognized as capable of conducting full scale impact testing of highway hardware. Testing in compliance with FHWA accepted procedures is then performed on the feature. The results, in the form of a test report and related documentation, are submitted by the developer or, at the request of the developer, the testing agency to the Office of Engineering. If the testing and performance of the feature are acceptable and sufficient detail on the design and operation of the device are provided, the Office of Engineering will issue a letter

to the petitioner (the developer or other person requesting acceptance of a feature) indicating acceptability of the feature for use on the NHS and the Report 350 test level for which it qualifies. This letter may also cite limitations on the feature's acceptability, such as the maximum mass of pole that may be used with an accepted breakaway feature or other physical or installation requirements. Copies of acceptance letters are sent to the FHWA's regional offices so that they are kept informed of additions or changes to the list of acceptable hardware and, in turn, pass the information on to state highway agencies through FHWA division offices. Should the petitioner differ with the FHWA's finding on the crashworthiness of a feature the finding can be appealed in writing. The appeal should be directed to the Office of Engineering at the address given on the last page of this attachment and include a statement of the point(s) of difference with the FHWA, the action desired, and documentation supporting the claim(s) being made.

There are some features that, by their nature, are nearly certain to be safe and others that are so similar to currently accepted features that there is little doubt that they would perform acceptably. For these features, the FHWA may, on a case-by-case basis, not require qualification testing or may accept abbreviated or unique qualification procedures as the basis for their acceptance. Flexible delineator posts are an example of hardware that is unlikely to require full-scale crash testing. Barriers or breakaway supports that are substantially the same as previously accepted crashworthy hardware may also be accepted under this provision, again, on a case-by-case basis.

It should be noted that acceptance of a design by FHWA does not ensure acceptance or use by the various state highway agencies. They may reject a design or place limitations on its use for a variety of reasons—placing their own interpretation on test results, requiring additional testing, or requiring in-service evaluation. Also, should the FHWA discover subsequent to the issuance of an acceptance letter that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, it reserves the right to modify or revoke its acceptance.

The FHWA may also revoke an acceptance if a device is promoted as acceptable under conditions that are significantly divergent from the test conditions. Any deliberate misrepresentation or withholding of the conditions of FHWA's acceptance of a feature by the supplier of a feature will be cause for withdrawal of acceptance.

Crashworthy hardware items other than those accepted by FHWA Headquarters, it should be noted, could be acceptable for use on the NHS. As already stated, the FHWA's Office of Engineering reviews test results and issues acceptance letters as a service to developers and users to help provide continuity and uniformity in evaluations. However, it is not a requirement that an acceptance letter be issued by the Office of Engineering for crashworthy devices to be used on the NHS. If, for a particular device, it can be demonstrated to the satisfaction of a state highway agency that a device has been tested and evaluated in accordance with acceptance procedures recognized by the FHWA, and the results are satisfactory, that device could be accepted by that state, with concurrence by its FHWA division office, for use on the NHS within that state. However, should this alternative course be followed, in the interest of technology transfer, the

division office, through its regional office, should submit the crash test reports and other documentation upon which its acceptance is based to the Office of Engineering for information and possible Headquarters concurrence and distribution.

Crash Testing: General

Developers who are new to the field of highway safety hardware may find Appendix A useful. It contains a list of testing agencies that have experience in testing roadside safety hardware for state highway agencies, developers, and the Federal Government. This list is not meant to be all-inclusive nor is it an endorsement of these organizations. It is intended to provide a starting point that developers can use in determining where they might have the appropriate tests performed. Other facilities in the U.S. or in other countries may also be qualified to satisfactorily perform the tests. FHWA reserves the right not to accept test results if the competence of the crash test laboratory that performed the test is uncertain or if non-standard test equipment or procedures were used. FHWA may accept the competence of a foreign laboratory based on certification through an FHWA recognized procedure, governing agency, or standards review organization.

Various test levels (combinations of vehicle size and impact angle and speed) have been included in the Report 350 crash test matrices to permit tailoring the performance and cost of highway safety features to meet specific site requirements. When developing a crash testing program for a particular device careful attention should be paid to selecting the appropriate test level. Selection procedures for the various test levels are yet to be developed. However, work on developing such procedures is currently (1997) underway under an NCHRP project. FHWA acceptance letters will acknowledge the test level to which a device has been crash tested and is acceptable. It will be assumed that until nationally recognized selection procedures exist user agencies will, by some consistent, rational means, determine where a feature of a demonstrated test level is appropriate for use.

Devices intended to serve as permanent or temporary traffic barriers (longitudinal barriers, terminals, or crash cushions) must, as a minimum, qualify under Report 350 test level 1 test procedures and acceptance criteria to be accepted for such service. Devices that do not qualify as traffic barriers may find use as channelizing devices or for delineation provided they meet Report 350 guidelines for work zone devices and are consistent with the *Manual on Uniform Traffic Control Devices* requirements. They will not, however, be acceptable for use where a longitudinal barrier is needed to shield a work area.

All hardware that is to be used with a device in service must be in place during the crash test, whether it is a functional part of the system or an ancillary feature such as a warning sign—sign supports need signs, delineator posts need delineators, breakaway luminaire supports need mast arms and the equivalent of luminaires, etc. Barriers that are to be used with glare screens, signs, luminaire supports, handrails, or other hardware mounted on top should be tested with these devices in place. An exception to this requirement may be a light-weight fabric or pliable membrane snow or debris cover if its effect on crash performance can be judged inconsequential.

The intention to use such a cover with a device and a full description of the cover must be specifically covered in any request for acceptance.

The developer should also carefully choose which version of a device is to be tested. If a number of different sizes are proposed for use, then the "worst case" conditions, if predictable, should be tested. It may be that "worst case" conditions are not obvious and more than one version of a device will need to be tested. The FHWA Office of Engineering is willing to review a proposed test program to assist in determining an adequate number of tests to fully qualify a device and its variants.

To date (1997), most crash testing has been done on level or nearly level test sites. The terrain on which a feature is located or over which an impacting vehicle may traverse (either pre- or post-impact) can have significant effects on the outcome of a crash into a given feature. Therefore, a request for acceptance should include, preferably in the test report, a discussion of the site conditions—foundation and topography—for which a feature is intended to be used and the limitations of the testing program to evaluate the range of expected service conditions.

Below is a section containing comments on specific aspects of testing various types of highway features. These comments are followed by a section on "Submission Requirements", which describes what needs to be supplied to the Office of Engineering when requesting FHWA review and acceptance of a crashworthy highway feature. Appendix B is a checklist citing information that FHWA has found to be essential in its evaluation of the crashworthiness of hardware. It is recommended that this list be carefully reviewed in designing a testing program and in preparing a request to the FHWA for acceptance of a feature.

Crash Testing: Specific Features

Sign and Luminaire Supports

Crashworthy sign and luminaire supports are designed to break away or yield when struck by a vehicle. When a proposed breakaway support design includes two or three posts within a 2.1-meter span all supports must be struck by the test vehicle. Testing conditions and evaluation criteria for determining acceptable breakaway performance are found in the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, 1994, (Support Specifications) and in Report 350. Please note that soil conditions are critical when considering the crashworthiness of many breakaway supports. Supports qualified in "standard" soil may not work in "weak" soils and thus may not be acceptable in weak soils. The use of a concrete foundation or a soil plate will also affect the performance of the support and must be documented.

Full-scale crash tests, with the prescribed Report 350 test vehicle, are applicable to all types of breakaway hardware. Tests with pendulums or reusable bogie vehicles are acceptable for most breakaway supports, exceptions being base bending or yielding supports. These supports must

be tested using an automobile because no surrogate test devices have been approved that replicate the interaction between the vehicle and the support. Pendulum testing of base bending or yielding supports may be permitted on a case-by-case basis to evaluate the relative performance of supports that have previously been qualified using automobiles.

The support hardware must perform satisfactorily at impacts between 35 km/h and 100 km/h, per Report 350. Since the higher speed tests cannot be run on a pendulum test facility, FHWA has allowed high speed results to be estimated using a procedure previously detailed in the discontinued FHWA Notice N 5040.20, dated July 14, 1976. That procedure is described here in Appendix C. This extrapolation method, when checked, has nearly always been found to be conservative and could result in the rejection of breakaway features that would actually pass full scale high-speed tests.

Testing parameters and acceptance criteria for breakaway supports are as follows:

1. The key criterion for acceptable dynamic performance in the Support Specifications is a maximum change in velocity of 16.0 ft/sec (4.88 m/sec) in a 1,800-pound (818-kg) test vehicle. The velocity change to be compared to the maximum allowable in the standard is the occupant impact velocity. This is the calculated speed at which a hypothetical unrestrained occupant impacts the car's interior after traveling a distance of two feet (flail-space distance) relative to the vehicle after vehicle contact with the feature. Report 350 calls for a maximum velocity change of 5.0 meters per second (16.4 feet per second) based on a 0.6-m (1.97-foot) flail space distance. In adopting Report 350, the FHWA recognized this higher occupant impact velocity as an acceptable upper limit and also recognized the 35-km/h and 100-km/h (21.7-mph and 62.1-mph) test speed range and the 820 kg (1808-pound) test vehicle. Because Report 350 acceptance criteria are slightly less demanding than were the criteria in the 1985 or 1994 Support Specifications or the Report 230 guidelines, breakaway hardware meeting these earlier criteria do not have to be re-qualified to be accepted under Report 350 criteria.

2. The maximum stub height remaining after a support breaks away, measured above a 1500-mm chord, as specified in the Support Specifications, shall not exceed 100 mm. (This is intended to prevent the vehicle undercarriage from snagging on the broken stub and to minimize vehicle instability if a wheel hits the stub.)

3. The occupant compartment must not be penetrated nor seriously deformed. Maximum roof crush will be evaluated on a case-by-case basis. However, in no case when a breakaway pole falls onto a test vehicle will a roof crush greater than 150 mm (6 inches) be found acceptable.

4. Features, primarily luminaire supports, that are expected to contain electrical wiring are to be tested with non-energized wiring of the size, structure, and configuration expected to be used with the feature. The objective of including wiring in the test installation is to

evaluate both the effect the wiring might have on a support's breakaway performance and the potential for the creation of an electrical hazard when the support might be knocked down. Where alternative wiring designs are likely to be used with a support, the design expected to most adversely affect breakaway performance is to be used. (This criterion of testing with wiring in place has not been required in the past. The FHWA, however, will not require retesting of previously accepted supports tested without wiring. It should be noted that, while neither the current Support Specifications nor Report 350 call for testing supports with wiring in place, the requirement is expected to be included in the Support Specifications shortly.)

Because pendulum and bogie testing of luminaire supports, which, as indicated, the FHWA will accept, do not reveal the consequences of a support falling on the roof of an impacting vehicle and even automobile testing does not investigate the full range of potential consequences from a support falling on a vehicle, based on test observations and engineering judgement, the FHWA has set upper limits on the support masses and heights it will find acceptable even where analysis or testing appear to indicate acceptability of greater mass or height supports. The maximum acceptable luminaire support mass is 450 kg (992 pounds) and the maximum luminaire support height is 18.50 m (60.7 feet). These values are up from the limits of 272 kg (600 pounds) and 15.2 m (50 feet) cited a few years ago. Any further increase in these limits will have to be based on full-scale crash testing and an investigation of the range of vehicle roof crush characteristics that go beyond the recommended testing procedures in Report 350.

Traffic Barriers (Longitudinal Barriers, Transitions, and Crash Cushions and Terminals)

Report 350 contains recommended testing procedures, reporting requirements, and criteria for determining and documenting the acceptable crashworthy performance of traffic barriers. The required number of tests, test speeds, impact angles and locations, and test vehicles vary, depending upon the test level and whether the article to be tested is a longitudinal barrier, barrier transition, or terminal or crash cushion. If there is any question concerning the total number or type of tests to be run, the developer may wish to discuss this issue with the FHWA Office of Engineering beforehand and reach a preliminary agreement on an appropriate test matrix.

The required strength-test (containment-test) vehicle for the first three of the six test levels suggested for longitudinal barriers is a 2000-kg (4,409-pound) ¾-ton pickup truck. The strength-test vehicle for test level 4 is an 8000-kg (17,637-pound) single-unit truck. The strength-test vehicles for test levels 5 and 6 are 36 000-kg (77,366-pound) tractor semi-trailer combinations. The difference between the latter two test vehicles is that for test level 5 the trailer is a van-type and for test level 6 the trailer is a tanker.

Bridge railings are longitudinal barriers and are treated as such in Report 350. However, because of some unique history connected with their testing and acceptance they are covered separately below.

Bridge Railings

Bridge railings, as stated, are longitudinal barriers and are to be tested as such with regard to the application of Report 350. Their design is covered in both the AASHTO's *Standard Specifications for Highway Bridges* and the 1994 *AASHTO LRFD Bridge Design Specifications* (LRFD), which reflects the design approach in the 1989 AASHTO *Guide Specifications for Bridge Railings* (Guide Specifications). As can be inferred from comments below, the testing criteria in the LRFD have been effectively superseded by Report 350.

The FHWA policy of requiring crash tested bridge railings was established by the memorandum "Bridge Rails", dated August 28, 1986. Typically, individual states have sponsored the testing of their own bridge railings and implemented the new designs upon receipt of acceptable crash test results.

The LRFD and the Guide Specifications contain guidance for testing bridge railings that differs from the guidance in Report 350 in that they recognize only three "Performance Levels." These performance levels approximately match three test levels in Report 350, test levels 2, 4, and 5. The FHWA recommends that all bridge railing testing now be conducted in accordance with Report 350 and that Report 350 test levels 2, 4, and 5 be substituted for the 1994 LRFD performance levels 1, 2, and 3, respectively. (The AASHTO is considering, and is likely to adopt in the near feature, a revision in the LRFD to incorporate the six tests levels cited in Report 350.)

FHWA has issued two memoranda (the cited August 28, 1986, memorandum and one dated August 13, 1990) listing a total of 47 railing designs that met full scale test requirements at the time that they were tested and may be considered acceptable for use on the NHS at specified performance levels. A third memorandum dated May 30, 1997, updated these earlier listings. This new memorandum provides guidance on determining an acceptance test level equivalent to a Report 350 test level for bridge railings tested under the railing section of the LRFD, or it's predecessor, the AASHTO *Guide Specifications for Bridge Railings*, or other guidelines. It also identifies additional railings tested under the LRFD, Report 350, or other guidelines.

Work-Zone Traffic Control Devices and Miscellaneous Features

In addition to truck mounted attenuators (TMAs), which are covered separately below, Report 350 provides guidance for crash testing other work zone features—work zone signs, barricades, channelizing devices, etc.—and insubstantial features such as delineator posts. Because of the nature of these features some of the test procedures are less rigorous than those for other features. For example, under some conditions, low-speed tests may not be required and for tests of free-standing objects with masses less than 45 kg, reduced instrumentation is permitted. (See Report 350 section 3.2.3.2.) For determining this 45-kg limit, Report 350 exempts ballast mass from the mass of the feature if "... the ballast effectively does not contribute to the change in the vehicle's velocity upon impact with the device." However, the ballast mass, its location, and its means of attachment must be clearly described in the drawings and specifications to be provided

under section 6.1 of Report 350.

Note that FHWA acceptance of a device as meeting crashworthiness requirements does not imply that it has been determined that the device is in conformance to the *Manual on Uniform Traffic Control Devices* (MUTCD). Acceptance letters for crashworthy traffic control devices will carry a disclaimer to that effect. However, if, in the opinion of the FHWA, a crash tested device submitted for acceptance is clearly out of conformity with the MUTCD the entire submission may be returned to the petitioner.

There is a wide variety of devices used in work zones, some of which are not normally found on the roadside or in the traveled way outside of work zones. For purposes of determining the level of effort needed to demonstrate crashworthiness, work zones devices and miscellaneous features will be divided into four categories:

1. The first category contains those small and lightweight channelizing and delineating devices that have been in common use for many years and are known to be crashworthy by crash testing of similar devices or years of demonstrably safe operational performance. These include plastic or rubber cones and tubular markers, flexible delineator posts, and plastic drums with no lights, batteries, signs, etc. added. If ballast is used, it must be located at ground level in accordance with the manufacturers instructions. For devices to be included in this category there must be virtually no potential that they will penetrate windshields, cause tire damage, or have a significant effect on the control or trajectory of an impacting vehicle. FHWA will not issue letters of acceptance nor maintain a list of the many individual devices in this category. These devices may be allowed based upon the developer's self-certification if the device:

    a. is built to a specification for a device for which the crashworthiness has been validated by crash or surrogate testing, or

    b. is a type of device that is being accepted as being crashworthy on the basis of crash test experience with similar devices or years of demonstrably safe operational performance. (Simplified crash testing showing that a device poses no risk to impacting vehicle occupants may be used to support the manufacturers certification. This simplified testing must, as a minimum, be documented by a written report, observed by an independent, impartial observer, recorded on videotape, and include a means, other than the test vehicle's speedometer, for determining the vehicle speed at time of impact.)

Self-certification will be subject to approval by the individual highway agencies.

Devices with a top-mounted warning light will only be included in this category if they satisfy condition 1.a.

2. The second category includes devices that are not expected to produce significant vehicular velocity change, but may otherwise be hazardous. All or parts of the device may be substantial enough to penetrate a windshield or injure a worker or they may cause vehicle instability when driven over or should they become lodged under a vehicle. Testing of devices in this category will be required. However, they may, as mentioned above for devices of 45 kg or less, qualify for the reduced testing requirements cited in section 3.2.3.2 of Report 350. Lesser instrumentation than required in Report 350 may be acceptable. Depending on the device, videotaping may be substituted for high-speed film photography in recording test results and instrumentation in the vehicle may be omitted. Examples of this class are barricades, portable sign supports, intrusion detectors and alarms, and drums, vertical panels, or cones with lights.

Devices in this category could merit an FHWA acceptance letter unless it is determined that a blanket acceptance (or prohibition) is warranted based on experience with or testing of like devices. In order to help highway agencies evaluate the potential hazards to workers (bystanders) from work zone devices and determine any limitations to be placed on their use or location, the masses and trajectories of elements of a device launched in its testing must be recorded and reported.

If sufficient crash testing is done to indicate that a certain class of device, with any ancillary feature(s), is crashworthy, then this class may be moved to Category 1. FHWA will make the determination whether to move a class of devices to another category, although petitions from industry, documented by crash testing and design details, are welcome.

3. The third category is for hardware that is expected to cause significant velocity changes or other potentially harmful reactions in impacting vehicles. Hardware in this category must be tested to the full requirements of Report 350. If requested, individual letters of acceptance will be issued by the FHWA for crashworthy devices in this category. Barriers, fixed sign supports, crash cushions, and other work zone devices not meeting the definitions of category 1 or 2 devices are examples from this category.

Because of the large and expensive inventory, long life, and lack of alternative applications for work zone crash cushions and freestanding concrete work zone traffic barriers and the timing of the availability of Report 350 qualified hardware of these two types, the FHWA has concluded that it is appropriate to extend the deadline for requiring that these devices comply with the recommendations in Report 350. Therefore, until October 1, 2002, the FHWA will accept the use of work zone crash cushions and freestanding concrete work zone traffic barriers on the NHS, provided they have been crash tested and found acceptable under procedures and criteria at least as stringent as those recommended in Report 230, assuming the small test vehicle had a mass of 820 kg (1800 pounds). (Actually, there are many concrete work zone barriers that do not meet these criteria and that should be phased out of service as soon as possible.) To be used on projects on the

NHS advertised for bids or constructed with state forces or through force account work on or after October 1, 2002, work zone crash cushions and freestanding concrete traffic barriers must be shown to be crashworthy under the guidelines in Report 350.

4. The last category, which is actually a subset of category 3, includes portable, usually trailer-mounted, devices such as area lighting supports, flashing arrow panels, temporary traffic signals, and changeable message signs which are often used in or adjacent to the traveled way. While they have significant value in the work zone by contributing to safer traffic operation, these devices may cause great harm to occupants of impacting vehicles. Even though accident experience to date shows that crashes with these devices are rare, it is believed that they should be made crashworthy and meet the recommended acceptance guidelines in Report 350 if they are to be used, unshielded, in the clear zone on the NHS. However, in the belief that, as currently configured and deployed, these devices provide a net benefit to motorists and that it is unlikely that crashworthy versions can be developed in time to reasonably meet the October 1, 1998, compliance deadline cited above, the FHWA is setting October 1, 2002, as the date at which it will no longer accept the unshielded use of devices in this category on roadways or within clear zones on the NHS unless they have been proven crashworthy. (In the interim, as should be done with these devices even if proven crashworthy, they should be positioned and operated in as safe a manner as practical. This would mean, where reasonable, placing them behind crashworthy barriers or shielding them with a TMA or crash cushion. For those devices that it is decided appropriate to operate unshielded within the clear zone, they should be highly visible, both in and out of service, and be removed from the clear zone as soon as practicable after they are no longer needed.)

Some work zone traffic control devices are normally used in a series to channelize traffic. There is the potential that singly some of these devices may have little effect on an impacting vehicle but, when struck in multiples, may cause vehicle instability or occupant compartment intrusion. Also, because of the nature of their configurations, many of these devices can be easily turned or upset under normal operating conditions. To address both of these possibilities, when testing devices that are typically installed in series, it is recommended that crash tests include two of these devices placed in a row aligned with the path of the test vehicle. For a 100-km/h test the devices should be spaced 6 meters apart and the second device should be either turned 90 degrees relative to the first or laid on the ground, whichever is judged the "worst case" orientation for the device in question.

Truck Mounted Attenuators

The guidelines in Report 350 for assessing the crashworthiness of truck mounted attenuators (TMAs) are to be followed except that, until state-of-the-art developments indicate that practical and economical TMAs can fully meet the guidelines in Report 350 under test 3-50, the FHWA will accept a modified test 3-50, provided an unmodified test 2-50 (70 km/h, small-car test with the host vehicle blocked to prevent movement) is run and passed. The modified 3-50 test the FHWA

will accept for qualifying a test level 3 TMA is a 100-km/h small-car test where the host vehicle only has its brakes set and is in second gear. This assumes all other Report 350 test level 3 requirements are met. (For information and comparison with other TMAs, the FHWA suggests that the optional tests 2-52 and 2-53 or 3-52 and 3-53, as appropriate, be run and reported on all TMAs, even though TMAs may be accepted without passing these tests.)

A recommended mass for the TMA host vehicle, which will affect a TMA's performance in an unblocked test, is given in Report 350. The mass of the host vehicle, the mass of any ballast in the host vehicle, and the manner in which the ballast is secured in the host vehicle are to be reported in the test report. Also, any structural features or modifications required in the host vehicle to receive the tested TMA are to be reported.

Submission Requirements

Items submitted with a request for an FHWA finding that a feature is crashworthy and acceptable for use on the NHS must fully identify: a) the feature(s) tested; b) the conditions and results of the testing; and, if acceptance is being sought for any variations in design or construction details or procedures from those covered in the documentation of the testing of the feature, c) the complete design, construction, and installation details and specifications for the version(s) of the feature for which acceptance is being sought. It will be the responsibility of the petitioner to provide documentation of the applicability of the testing actually done to assess the acceptability of a feature or features differing from the tested article(s). This documentation is to be included with the request for acceptance and be sufficiently complete and detailed to fully support the conclusion of applicability.

Because the acceptance letter from the FHWA Headquarters is copied to FHWA field offices to notify those offices of Headquarters action, information is included with the acceptance letter that might otherwise not be necessary to include. One such item is a copy of a letter-sized (8.5"x11" or I.S.O. A4)(216 mm x 279 mm or 210 mm x 297 mm) engineering drawing or set of engineering drawings describing the accepted feature in sufficient detail and specificity that an observer in the field could use the drawing(s) to confirm that a purported installation of the accepted feature is in substantial conformance with what was found acceptable. Thus, two separate copies of a high-quality, reproducible, letter-size, engineering drawing or set of drawings showing all pertinent details and installation requirements of the version(s) of the feature for which acceptance is being sought are to be included with the request for acceptance. (These can often simply be copies or reductions of a drawing or drawings included with the documentation of the crashworthiness of the feature.) Additional guidance on items to be included with a request for acceptance of a feature is given below.

Report 350 contains rather complete guidance on the acquisition, reporting, and analysis of data on the testing of highway features. Appendix D at the end of this attachment is a table containing suggested evaluation factors and terminology that the FHWA suggests using as a supplement to Report 350 to provide a standard evaluation format for the visual assessment of test results.

A submission requesting FHWA acceptance of a highway feature must include two copies of a test report prepared according to the guidance in Chapter 6 of Report 350 showing, except as modified in these guidelines, that Report 350 testing procedures were followed and that Report 350 acceptance criteria were met. Note that it is not sufficient to report the nominal test conditions, design details, or specifications. The tolerances and ranges in these must be evaluated against the actual test conditions and the details of the tested device to determine the relevance of the testing and the acceptability of the device and the proposed tolerances and specifications related to it. Therefore, in setting up and conducting tests and reporting test results, particular attention should be given to the discussions concerning test articles covered in Chapters 2, 4, and 6 of Report 350. The objective is to accurately report the as-built foundation conditions, test article geometry, and material characteristics of what was actually tested, not just the nominal design dimensions and specifications for the feature, which, as indicated below, should also be reported. Ideally, all materials for a test installation should be examined before they are installed to ensure that they are representative of what will actually be supplied in service, with special vigilance for elements that, while within specifications, might falsely represent performance under service conditions. This process may require obtaining mill certification reports or actually running physical material tests on critical components of a feature. All materials used in appurtenances shall be declared, using chemical rather than proprietary names to describe synthetic materials. Descriptions and material specifications for all components, including fastener hardware, should be included or referenced.

In addition to two copies of test reports and a VHS cassette video of the full sequence of tests, the following must also be supplied:

- The previously cited two sets of a reproducible letter-size drawing or set of drawings showing the feature and its installation in sufficient detail to be used to make dimensional checks of service installations,

- If not included in the test report, two complete sets of material and installation specifications for the proposed production model of the feature, including copies of any cited specifications (except for AASHTO or ASTM specifications frequently used in the highway field).

- Because of FHWA's regulation regarding the use of proprietary products on Federal-aid projects, the request for acceptance must identify any patent or proprietary rights held on the feature or elements of the feature for which acceptance is sought. If the feature is proprietary a statement will be included in the acceptance letter indicating the regulations that must be meet if the feature is to be specified on Federal-aid projects.

The following additional documentation is desirable and may be required:

- Two sets of prints of photos included in the test report. These will be required unless the reproductions in the test report are near photo-print quality. (Experience has shown that half tone and xerographic reproductions of photos are often not adequate for review of before and after conditions or failure details.)

- One set of 16-mm film coverage of tests. This will be required if the video copy of this coverage is not of sufficient quality to be used in interpreting the test results.

Confidentiality of Submitted Items

The FHWA recognizes that some of the items and information it needs to evaluate the crash worthiness of a feature may be proprietary and as such a petitioner may want them to be held in confidence. Within the limits of law and the guidance below, the FHWA will honor written requests for confidentiality. However, in the interest of advancing technology, if a feature is found acceptable, unless the petitioner requests otherwise, the submitted films and video tapes may be sent to the FHWA/National Highway Traffic Safety Administration National Crash Analysis Center (NCAC), which makes such items available to the public without restriction. If the petitioner requests that these items not be sent to the NCAC or if the items are copyrighted, the information will be retained in the Office of Engineering and, upon request, will be available for viewing by interested individuals. The FHWA will not consider the test results or related photographic documentation or test data as confidential. However, it will respect restrictions on copying any copyrighted items, except that the letter sized drawings to be submitted for FHWA use in preparation and distribution of an acceptance letter must not be copyrighted. Items, such as detailed design drawings or specifications needed to document the testing of a feature or features as well as the exact character of the feature or features for which acceptance is sought, that the petitioner wishes to declare proprietary and confidential must be so marked and physically separated from the body of the test report or reports.

Addressing Requests for Acceptance

Submissions requesting acceptance of features should be mailed to:

DIRECTOR, OFFICE OF ENGINEERING
FEDERAL HIGHWAY ADMINISTRATION (HNG-1)
400 7TH ST. SW
WASHINGTON, DC 20590

HNG-14
25 Jul 97

Testing Agencies with Significant Experience in Testing Roadside Safety Features*

California Department of Transportation **
Box 19128
5900 Folsom Boulevard
Sacramento, CA 95819

Contact: Mr. Richard Peter
(916)227-7257 FAX: (916)227-7117

Calspan Transportation Sciences Center
P.O. Box 400
4455 Genesee Street
Buffalo, NY 14225

Contact: Mr. Saverio Pugliese
(716) 631-6839 FAX: (716)631-6843

E-Tech Testing Services
3617-B Cincinnati Avenue
Rocklin, CA 95765

Contact: Mr. John LaTurner
(916) 645-8188 FAX: (916) 645-3653

ENSCO, Inc.
5400 Port Royal Road
Springfield, VA 22151

Contact: Mr. Dale Stout
(703) 321-9000 FAX: (703) 321-7863

Southwest Research Institute
P.O. Box 28510
San Antonio, TX 78284

Contact: Mr. John W. Strybos
(210) 522-2449 FAX: (210) 522-3042

Texas Transportation Institute
Texas A&M University
College Station, TX 77843

Contact: Dr. C. Eugene Buth
(409) 845-6375 FAX: (409) 845-6107

University of Nebraska - Lincoln
Civil Engineering Department
W350 NEB Hall
Lincoln, NE 68588-0531

Contact: Dr. Dean L. Sicking
(402) 472-9332 FAX: (402)472-8934

Transportation Research Center Inc.
10820 State Route 347
East Liberty, Ohio 43319-0367

Contact: John C. Stultz
(937)666-2011 FAX: (937) 666-5705

Crash Safety Research Center
Pennsylvania Transportation Institute
Pennsylvania State University
201 Research Office Building
University Park, PA 16802

Contact: Robert J. Wollyung
(814) 865-7931 FAX: (814) 865-3039

Federal Outdoor Impact Laboratory ***
Turner Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101

Contact: Mr. Richard E. King
(703) 285-2468 FAX: (703) 285-2679

* Some agencies may not have the capability to conduct all Report 350 tests.

** Services usually limited to State-sponsored research.

*** Testing usually limited to State- or FHWA-sponsored research.

APPENDIX B

Crashworthy Features - FHWA Acceptance Request Submission Checklist

Following is a listing (not necessarily complete) of items to be included with a request for FHWA review and acceptance of a crashworthy highway feature. Failure to supply these items, if applicable to the feature, or the submission of listed items that are incomplete or inaccurate or of poor graphic or visual quality, will delay processing a request for a feature's acceptance. To reduce the potential for problems caused by insufficient information at submission time or undesired restrictions being placed on the acceptability of a feature, it would be prudent to consult this checklist when developing the testing plan and procedures for demonstrating the acceptability of a feature.

1. Two copies of acceptance qualification test report(s) and related supporting documentation, such as films, videos, photographs, etc., prepared in accordance with guidelines in NCHRP Report 350 and containing the following: _____

   A. Information to be included on article(s) tested:

      1.) Complete engineering drawings of as-tested feature(s) showing actual dimensions of all critical elements and their locations. Note that ancillary hardware, such as signs mast arms, lights, electrical wiring, glare screens, handrails ,etc., that are to be used with a feature is to be tested with it and needs to be fully described. In addition, any items, such as snow or debris covers, that are to be used with a device but are omitted from tests are to be identified and fully described. Further, for work zone features that are to be tested in pairs, the locations of the individual features are to be given, along with a discussion of the basis for selecting the tested orientation. _____

      2.) Complete descriptions of the material properties of all critical elements of the tested features(s). _____

      3.) Description of installation or erection procedures. _____

      4.) Complete description and characterization of foundation or mounting conditions, including special test mounting structures, support pavement, soil types(s), soil placement and compaction, soil moisture content, etc. _____

      5.) Documentary video (VHS preferred) and or photographs of test installation(s). _____

B. Information to be included on test(s) conducted:

1.) Complete detailed information on relevant features of the test vehicle(s) or testing device. _____

2.) Complete, precise information on test(s):

a.) Names of principals responsible for conducting test(s) _____

b.) Date(s) and time(s) _____

c.) Location(s) _____

d.) Current (at test time) and antecedent (10 days ±) weather and groundwater conditions—particularly, anything that might affect material properties or foundation conditions. _____

e.) Complete information on test instrumentation and test procedures, including identification of and justification for any deviations from Report 350 guidelines. _____

f.) Complete information on actual impact conditions (impact location, speed, angle, etc.) and a showing that the actual conditions were within allowable tolerances. _____

g.) Complete report on test results as recommended in Report 350, plus documentation for any inferences or extrapolations, such as estimating high-speed breakaway performance of a device on the basis of performance in a low-speed pendulum test. _____

3.) Composite video copy (VHS preferred) of test films. (The copies of the test films to be available if requested.) _____

4.) Documentary video and photographs and measurements of post-crash conditions of feature(s) and test vehicle(s) or test device(s). The information submitted with the initial acceptance request should be sufficient to clearly illustrate the after-test conditions of the tested feature and the test vehicle or device. However, all the information gathered, which should be sufficient to permit a detailed postmortem analysis of the crash results, need not be submitted initially but should be available to clarify any questions that might arise during FHWA's evaluation of the acceptability of a feature. _____

C. Certification of the capability of the testing organization may be required. (Currently no formal certification procedures have been adopted in the U.S.)

2. Two sets of documentation describing the feature(s) and service conditions (including test level and site and terrain and foundation conditions) for which acceptance is requested (preferably to be included as part of the test report and related documentary materials and supported by evaluations by the testing agency).

   A. Complete, accurate, and legible engineering drawings and specifications covering manufacture and installation of the feature(s), including material and dimensional tolerances and any required installation limitations or procedures. In addition to the drawings just cited, unless they meet the following criteria, a drawing or drawings suitable for reproducing by photo copying and that show sufficient details and dimensions to permit one to confidently identified the feature for which acceptance is requested are to be supplied. Desirably, these drawings will be 8.5" x 11" (216 mm x 279 mm). However, I.S.O. A4 or 8.5" x 14" (210 mm x 297 mm or 216 mm x 356 mm) will be accepted. These drawings are intended for attachment to the acceptance letter, if issued, copies of which will be distributed to FHWA field offices.

   B. Complete description and chronology of any deviation(s) between the tested feature(s) and test installation conditions and the service design and installation conditions for which FHWA acceptance is sought, which would include the range in sizes or details of a feature for which tests of one, or at least less than all variations, are presented to show acceptability of the full rang. Along with this information, an independent assessment by a qualified organization, preferably the testing agency, of the significance these deviations might have on the in-service performance of the feature. Deviations to be evaluated will, of course, include differences between the test site terrain, which is to be described in detail, and expected service site terrains.

3. The request for acceptance must identify any patent or proprietary rights held on the feature or elements of the feature for which acceptance is sought.

4. Proprietary information submitted that the petitioner wishes the FHWA to treat as confidential should be so marked and physically separated from information on the conduct and the results of tests on the feature for which acceptance is requested, which the FHWA will make available for public inspection. Items that the FHWA will hold open for public inspection that the petitioner does not wish reproduced should be copyrighted. However, a non-copyrighted summary of test results should be included in the submission, along with the letter-sized drawings cited in 2.A., which must not be copyrighted.

Estimating High-Speed Breakaway Performance from Low-Speed Test Results

The following paraphrased and annotated excerpt from the discontinued FHWA Notice N 5040.20, "AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," dated July 14, 1976, presents formulas for estimating the high speed (60 mph or 100 km/h) breakaway performance of a signpost, luminaire support, or other breakaway device tested at low speed (20 mph or 35 km/h). These formulas were developed under the FHWA study, "Safer Sign and Luminaire Supports." The study results are contained in reports FHWA-RD-76-32, -33, -34, and -35, dated from February to October 1976.

From:

$$(\Delta MV)_H = \frac{V_L}{V_H}(\Delta MV)_L + b\left(V_H - \frac{V_L^2}{V_H}\right)$$

we obtain, in customary U.S. units [NCHRP Report 230 test speeds (29.3 to 88 ft/s)]:

$$(\Delta MV)_H = \frac{1}{3}(\Delta MV)_L + b(78.2\ ft/s)$$

or, in SI units [NCHRP Report 350 test speeds (9.72 to 28.78 m/s)]:

$$(\Delta MV)_H = 0.35(\Delta MV)_L + b(24.38\ m/s)$$

where:

ΔMV = vehicle momentum change
= vehicle mass (M) x vehicle velocity change ($V_{(L\ or\ H)} - V_X$)
$(\Delta MV)_L$ = measured vehicle momentum change in the low speed test
$(\Delta MV)_H$ = computed vehicle momentum change at the higher speed
V_L = measured impact vehicle velocity during low speed test

$$b = 1.1M_p\left(\frac{R^2}{R^2+D_o^2}\right)$$

V_H = extrapolated vehicle velocity at the higher speed
M_p = mass of support
D_o = distance from support impact point to support c.m.
R = radius of gyration of support about its c.m.

This formula is considered acceptable for supports that break free with little or no bending in the support. It has not been tested and therefore should not be used with base bending (yielding) supports.

APPENDIX D

Suggested Evaluation Factors

Passenger Compartment Intrusion

1. Windshield intrusion

    a. No windshield contact
    b. Windshield contact, no damage
    c. Windshield contact, no intrusion
    d. Device embedded in windshield, no significant intrusion
    e. Partial intrusion into passenger compartment
    f. Complete intrusion into passenger compartment

2. Body Panel Intrusion (Yes or No)

Vehicle Control and Threat to Bystanders or Other Vehicles

1. Physical loss of Control

2. Loss of Windshield Visibility

3. Perceived Threat to Other Vehicles from Debris or Vehicle Trajectory

4. Debris on Pavement

5. Mass, Size, Shape of Significant Debris

6. Trajectories of Vehicle and Significant Debris

Vehicle and Device Condition

1. Vehicle Damage

    a. None
    b. Minor scrapes, scratches, or dents
    c. Significant cosmetic dents
    d. Major dents to grill and body panels
    e. Major structural damage

2. Windshield Damage

   a. None
   b. Minor chip or crack
   c. Broken, no interference with visibility
   d. Broken and shattered, visibility restricted but remained intact
   e. Shattered, remained intact but partially dislodged
   f. Large portion removed
   g. Completely removed

3. Device Damage

   a. None
   b. Superficial
   c. Substantial, but can be straightened
   d. Substantial, replacement parts needed for repair.
   e. Cannot be repaired