Chapter 6

Test Documentation

6.1 GENERAL REPORTING RECOMMENDATIONS

O

f primary importance in the guidelines presented herein is the preparation of a comprehensive test report. The test(s) should be documented in sufficient detail so that, if necessary, others could repeat the test(s) and obtain similar results. Liberal use of photographs is encouraged to document before, during, and after test conditions. Reference should be made to Chapter 3 for key pre-test, test, and post-test parameters.

The test report should be prepared as a formal technical report. The guidelines presented herein are intended as minimum requirements. A testing agency may, at its own discretion, include additional details in its test reports. Also, individual user agencies may have different reporting requirements, and it may be advisable to review such requirements to ensure that they are covered in the test reports.

6.1.1 General Information

The following general information should be included with the test report:

* Title page
* Technical Report Documentation Page
* Disclaimer statement (if applicable)
* Acknowledgments (if applicable)
* Table of contents
* List of figures
* List of tables

The title page should include the title of the report, name(s) and affiliation(s) of the authors, name and address of the test facility, report number, sponsoring agency, and the date of the report. The federal Technical Report Documentation Page should be completed and included as part of the report. However, disclaimer statement and acknowledgments are optional and may be included if applicable.

6.1.2 Report Contents

A recommended table of contents for the test report is given in Table 6-1. In general, the report should include, as a minimum, the following chapters or sections:

***Introduction***. The introduction chapter should include the following sections:

* Problem statement—A description of the background of the study.
* Objectives—A listing of the project objectives.
* Scope—A description of the scope of the project, including any analytical studies and crash tests conducted.

***System Details***. The test article and test installation should be fully described with engineering drawings and material specifications. Key parameters that should be recorded are given in Section 3.4. The engineering drawings shall be drawn to scale with appropriate dimensions and labeling to facilitate their use by others. It is desirable to have the drawings prepared in an electronic format, suitable for inclusion into the updates of *A Guide to Standardized Highway Barrier Rail Hardware*(9) or *A Guide to Small Sign Support Hardware* (10). For test articles with multiple design drawings, only the system and installation drawings should be included in the main report. The remaining design drawings should be included as an appendix to the report.

As appropriate, any revisions to the design made during the course of the test program should be fully documented. The documentation should include a detailed description of the revisions and which tests are conducted with the revised design. Also, any special fabrication and installation procedures (such as heat treatment, weldments, bolt tension, galvanizing in critical stressed areas, etc.) that may influence impact performance should be delineated.

For test articles installed in soil, the soil conditions should be carefully documented, including type of soil used; why it was selected; its adherence to recommended specifications; installation procedures (e.g., drill and backfill, trench, etc.); dimensions of backfill (length, width, and depth; or diameter and depth); and any special installation details. Furthermore, the soil properties and strength as measured at the time of test should be documented with each crash test as well as the latest soil strength calibration results (see Figures 3-1 and 3-2 for details on reporting requirements on soil strength).

***Test Requirements and Evaluation Criteria***. A discussion of the test requirements should be presented, including the required crash test matrix and the actual crash tests conducted. If an abbreviated crash test matrix is used, the rationale for not conducting certain crash tests should be explained. Any prior testing of the device or feature should be referenced and the results summarized.

Also, the evaluation criteria for assessment of the crash test results should be delineated for each of the crash tests conducted.

***Test Conditions***. Detailed documentation of the test conditions is presented in this chapter, including test facility, vehicle tow and guidance system, properties of the test vehicles, and the data acquisition systems (both electronic and photographic). Any dimensions of the test vehicle(s) that fall outside of the recommended tolerances should be noted in the test report. The data acquisition systems should be fully described, together with the procedures used in calibrating and processing the data.

***Crash Test Descriptions***. Detailed documentation of each crash test conducted should be provided in separate chapters, including the impact sequence and post-impact vehicle trajectory, system and component damage, vehicle damage, occupant risk values, and a discussion summarizing the test and evaluation results. Test documentation should include a summary sheet of the test results that presents an overview of the crash test results with four or five sequential photographs. Additional documentation should include more closely spaced sequential photographs of all important camera views; documentary photographs showing the impact location, system damage, and vehicle damage; and tables and figures illustrating the extent of test article and vehicle deformation. It is desirable that weather conditions that may affect test results be reported, including those at the time of the test as well as those preceding the test (e.g., the extent of subfreezing or rainy weather).

***Conclusions and Recommendations***. A summary of all test results in both narrative and tabular forms should be provided with appropriate conclusions and recommendations.

***References***. A list of any references used or cited in the test report should be provided.

***Appendices***. Materials too bulky to be included in the main report should be presented in the appendices. Some typical items include detailed design drawings of the test article, occupant compartment deformation measurements, accelerometer data analysis, and documentation of in-situ soil test results for each of the crash tests.

TABLE 6-1. Recommended Table of Contents for Crash Test Reports

|  |
| --- |
| **I. INTRODUCTION** |
| 1.1 Problem Statement  1.2 Study Objectives  1.3 Scope of Study |
| **II. SYSTEM DETAILS** |
| 2.1 Test Article and Installation Details (including scaled drawings)  2.2 Design Modifications during Tests (if any)  2.3 Material Specifications  2.4 Soil Conditions (if applicable) |
| **III. TEST REQUIREMENTS AND EVALUATION CRITERIA** |
| 3.1 Crash Test Matrix  3.2 Evaluation Criteria |
| **IV. TEST CONDITIONS** |
| 4.1 Test Facility  4.2 Vehicle Tow and Guidance System  4.3 Test Vehicle(s)  4.4 Data Acquisition Systems |
| **V. CRASH TEST 1 (test number)** |
| 5.1 Test Designation and Actual Impact Conditions  5.2 Test Descriptions  5.3 Test Article and Component Damage  5.4 Vehicle Damage  5.5 Occupant Risk Values  5.6 Discussion (if applicable) |
| **VI. CRASH TEST 2 (test number)** |
| Repeat Chapter V for next crash test (if applicable).  Two crash tests are shown for illustration purposes. |
| **VII. CONCLUSIONS AND RECOMMENDATIONS** |
| 7.1 Summary and Conclusions  7.2 Recommendations (if applicable) |
| **REFERENCES** |
| **APPENDIX A. DETAILS OF TEST ARTICLE** |
| **APPENDIX B. CRASH TEST 1 (test number)** |
| B.1 Occupant Compartment Deformation  B.2 Accelerometer Data Analysis  B.3 EDR Data |
| **APPENDIX C. CRASH TEST 2 (test number)** |
| C.1 Occupant Compartment Deformation  C.2 Accelerometer Data Analysis  C.3 EDR Data |

6.1.3 Findings Presentation Formats

To facilitate comparison of findings from two or more testing agencies, Table 6-2 shows a list of items pertaining to the findings and their presentation format.

It is recommended that the report contain, for each crash test, a summary page with the following information, as shown in Figure 6-1. An example of the use of Figure 6-1 is shown in Figure 6-2. Note that data items that are not applicable may be omitted from the summary page, as deemed appropriate.

1. **Sequential photographs**—Provide a series of representative sequential photographs here. The sequential photographs may be taken from selected frames of high-speed film or video, or from frames of a sequence camera. They should cover, as a minimum, the time between impact and exit and may be extended as necessary to show the response of the vehicle/test article during the contact phase. For longitudinal barrier tests, an overhead view and/or a view parallel to the barrier is preferred. For terminal or crash cushion tests, an overhead view is preferred. For other features, a view perpendicular to the vehicle’s approach path is preferred.

2. **Plan view**—Provide the plan view of the installation, showing the overall layout of the installation, the impact point of the vehicle with the test article, and the post-impact trajectory of the vehicle and the test article.

3. **Cross-sectional view**—Provide, if appropriate, a cross-sectional view of the test article, showing basic dimensions, heights, and if applicable, the depth of embedment of the test article.

4. **General information**—Report the test agency, test number, and date of the test.

5. **Test Article**—Describe, to the extent possible and as space permits, the test article:

* Type—Identify basic type of article tested (e.g., longitudinal barrier/bridge rail).
* Installation length—Report the installation length of the test article. For a longitudinal barrier test, this is the length of the standard barrier section, exclusive of the end terminals. For a terminal test, it is the length of the terminal and the adjoining longitudinal barrier; lengths of each should be given separately. For a crash cushion test, it is the length of the cushion and backup structure, if necessary; lengths of each should be given separately. For a TMA, it is the length of the cushion and the support truck; lengths of each should be given separately. It is not applicable for tests of support structures, work zone traffic control devices, and breakaway utility poles.
* Key elements—Provide descriptions of the key elements of the test article, such as rails, posts, support structures, etc., and include, as appropriate, size/dimension and material properties.

6. **Soil conditions**—Report, if applicable, the soil conditions for the test article:

* Type of soil—Report the type of soil used and a note should be made if there are unusual soil conditions different from those recommended in Section 3.3.1.
* Soil strength—Report the measured soil strength at (1) initial calibration tests and (2) time of the crash test.

7. **Test vehicle**—Parameters of interest are as follows:

* Type/Designation—Indicate whether a production model vehicle (and its designation) or a surrogate (bogie or pendulum) test vehicle was used. For a production vehicle, also indicate the designation of the test vehicle used in the test (i.e., 1100C, 2270P, 10000S, 36000V, or 36000T).
* Vehicle make and model—Indicate actual make and model year if a production model vehicle was used or the make and model year simulated by the surrogate.
* Mass—See Section 4.2.1.1 for definition of these parameters.

8. **Impact conditions**—Report the actual impact conditions of the test, including:

* Speed—actual impact speed as determined from an electronic speed trap or film analysis.
* Angle—actual impact angle as determined from film analysis.
* Location/orientation—actual location of point of impact. Also, report the vehicle heading angle if the vehicle is in a non-tracking mode at impact.

9. **Exit conditions**—The exit conditions should be measured at the time the vehicle loses contact with the test article (see Section 5.2.3 for further discussion), including:

* Speed—actual exit speed as determined from film analysis.
* Angle—actual exit angle as determined from film analysis. Also, report the vehicle heading angle if the vehicle is in a non-tracking mode at exit.
* Report whether the exit box criterion is met or not.

10. **Post-impact trajectory**—Report the stability and the stopping distance (or point of final rest relative to the initial point of impact) of the vehicle. Also, report the rebound velocity of the vehicle if applicable.

11. **Occupant risk values**—Occupant risk values are computed as described in Section A5.2.2 of Appendix A and in Appendix F, including:

* Occupant Impact Velocity (OIV), and
* Ridedown Acceleration (RA).

12. **Test article damage**—Provide a brief summary of the damage to the test article.

13. **Test article deflections**—Report the permanent and dynamic deflections of the test article plus the working width during impact. These measurements normally apply to longitudinal barriers, terminals, crash cushions, and TMAs. Permanent deflection is the residual lateral displacement of the test article remaining after the impact. Dynamic deflection is the maximum lateral displacement of the test article on the traffic side that occurs during the impact. The working width is the maximum dynamic lateral position of any major part of the system or vehicle. These measurements are all relative to the pre-impact traffic face of the test article. For the working width, the height of the maximum working width should also be documented and reported.

14. **Vehicle damage**—Report damage to the vehicle (see Section 4.2.1.4 for discussion of Vehicle Damage Scale (VDS) and Collision Damage Classification (CDC). See Section 5.2.2 and Appendix E for discussion of measurement of occupant compartment deformation), including:

* VDS and CDC scales for exterior damage
* Occupant compartment deformation and penetration
* Extent and location of maximum occupant compartment deformation/intrusion
* Undercarriage damage to floorboard, fuel tank, oil pan, and rear trunk
* Windshield damage rating, if applicable

If available, report Event Data Recorder (EDR) data and airbag deployment information as an appendix to the test report.

As part of the documentation, a video of the test(s) should be prepared. The video should include a title block identifying the test, test conditions, date, sponsoring agency, before-and-after documentary coverage of the test article and vehicle, and high-speed views of the impact (both profile and overhead). Also, it is important that the test report contain an ample number of photographs of the pretest, test, and post-test conditions.

6.1.4 Assessment

For each crash test conducted, the impact performance of the test article should be discussed with regard to the three evaluation factors: structural adequacy, occupant risk, and post-impact vehicular trajectory. It is recommended that an assessment summary page, as shown in Table 6-3, be prepared to address each relevant evaluation criterion of Table 5-1. Note that example entries shown in Table 6-3 are for illustrative purposes only and are not all-inclusive.

In case of multiple crash tests, a table summarizing the results of the individual tests should be provided, as shown in Table 6-4. Again, the example entries shown in Table 6-4 are for illustrative purposes only and are not all-inclusive.

Finally, a conclusion should be presented as to acceptability of the impact performance of the test article based on results of the crash test(s). Recommendations should be offered as to modifications that may improve the impact performance and cost-effectiveness of the test article. Recommendations should be categorized as either desirable or essential. Known or predictable limitations of the test article, such as sensitivity to foundation conditions or effects of improper orientation of the test article, should be discussed. Recommended applications may also be identified.

TABLE 6-2. Recommended Format for Reporting of Findings

|  |  |  |
| --- | --- | --- |
| **Item** | **Description** | **Format** |
| Photography  Still  High-Speed Cine/Video | Before and after of test vehicle and test article  Selected sequential frames (8 minimum) during impact | Photos  Photos |
| Vehicle Accelerations | x, y, z components; filtered  (see Section 4.3.2) | Plotsa |
| Vehicle Angular Displacements | Roll, pitch, and yaw vehicular displacements | Plotsa and Maximum Values |
| Vehicle Trajectory | Vehicle trajectory and location of vehicle final rest | Scaled Drawing, Photos, and Narrative |
| Damage  Test Article  Deformation  Permanent  Dynamic  Key Elements  Vehicle  Exterior  Interior | Length of contact  Profile of deformation  Magnitude and location of maximum deformation  Damage to key elements  Damage to exterior  Damage to interior  Magnitude and location of maximum deformation | Narrative  Plota/Table  Photos and Narrative  Photos and Narrative  Photos and Narrative  VDSBb and CDSb Scales and NASSb Measurement Tech  Photos and Narrative  Deformation Measurement  Photos and Narrative |
| Optional  Dummy  Accelerations  Femur Load  Seat Belt  Other Instrumentation | x, y, z components of head and chest; (see Section 4.3.2)  Femur load cell  Seat belt load cell  Load cell, strain gauge, etc. | Plotsa  Plotsa  Plotsa  Plotsa |

a Plots should be scaled to maximize resolution of parameters.

b See Section 4.2.1.4.

TABLE 6-3. Example of Recommended Assessment Summary Page for Individual Crash Tests

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Evaluation Criteria** | | | | **Test Results** | **Assessment** |
| Structural Adequacy  A. Test article should contain and redirect the vehicle; the    vehicle should not penetrate, underride, or override the    installation, although controlled lateral deflection of the    test article is acceptable. | | | | Vehicle contained and smoothly redirected. | Pass |
| Occupant Risk  H. Occupant Impact Velocities (OIV) (see Appendix A,    Section A5.2.2 for calculation procedure) should satisfy    the following limits: | | | | Longitudinal OIV = 33 ft/s (10 m/s)  Lateral OIV = 8 ft/s  (2.5 m/s) | Pass |
|  | Occupant Impact Velocity ft/s (m/s) | | |
| Component | Preferred | Maximum |
| Longitudinal and Lateral | 30 (9) | 39 (12) |
| Vehicle Trajectory  N. Vehicle trajectory behind the test article is acceptable. | | | | Not applicable | Pass |

Note: Table entries are not all-inclusive and are for illustration purposes only. This table will typically require more than one page to   
complete.

TABLE 6-4. Example of Recommended Assessment Summary Page for Multiple Crash Tests

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Evaluation Factors** | **Evaluation Criteria** | **Test EXP-1** | **Test EXP-2** | **Test EXP-3** |
| Structural Adequacy | A | N/A | S | N/A |
| C | S | N/A | S |
| Occupant Risk | D | S | S | S |
| F | S | S | S |
| H | S | N/A | N/A |
| I | S | N/A | N/A |
| Post-Impact Vehicular Response | L | N/A | S | S |
| M | N/A | S | S |
| N | S | N/A | S |
| Test No. | | 3-31 | 3-38 | 3-39 |
| Pass/Fail | | Pass | Pass | Pass |

Note: S—Satisfactory

U—Unsatisfactory

N/A—Not Applicable

|  |  |  |  |
| --- | --- | --- | --- |
| 1. Sequential Photographs |  |  |  |

|  |  |
| --- | --- |
| 2. Plan View | 3. Cross-Sectional View |

4. General Information:

* Test Agency
* Test Number
* Date

5. Test Article:

* Type
* Installation Length
* Key Elements

6. Soil Conditions:

* Type of Soil
* Soil Strength

7. Test Vehicle:

* Type/Designation
* Make and Model
* Test Inertial
* Gross Static

8. Impact Conditions:

* Speed
* Angle
* Location/Orientation

9. Exit Conditions:

* Speed
* Angle
* Exit Box Criterion

10. Post-Impact Trajectory:

* Vehicle Stability
* Stopping Distance

11. Occupant Risk:

* Longitudinal OIV
* Lateral OIV
* Longitudinal RA
* Lateral RA

12. Test Article Damage: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13. Test Article Deflections:

* Permanent Set
* Dynamic
* Working Width

14. Vehicle Damage:

* VDS
* CDC
* Max. Deformation

Figure 6-1. Recommended Format of Summary Sheet for Crash Test Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 2214tb2p2_00176 | 2214tb2p2_00215 | 2214tb2p2_00284 | 2214tb2p2_00376 | 2214tb2p2_00490 |
| 0.000 sec | 0.078 sec | 0.216 sec | 0.400 sec | 0.628 sec |
|  |  |  |  |  |



* + - * Test Agency MwRSF
      * Test Number 2214TB-2
      * Date 10/12/04
      * Test Article Free-Standing Temporary Barrier
      * Total Length 200 ft (62.34 m)
      * Key Elements – Barrier

Description F-Shape Barrier

Length 150 in. (3810 mm)

Base Width 22.5 in. (572 mm)

Height 32 in. (813 mm)

* + - * Test Vehicle

Type/Designation 2270P

Make and Model 2002 Dodge Ram 1500 Quad Cab Pickup

Curb 4,777 lb (2167 kg)

Test Inertial 5,000 lb (2268 kg)

Gross Static 5,000 lb (2268 kg)

* + - * Impact Conditions

Speed 62.0 mph (99.7 km/h)

Angle 25.4 deg

Location/Orientation 4 ft (1.2 m) upstream barriers 8 & 9 joint

* + - * Exit Conditions

Speed 48.5 mph (78.1 km/h)

Angle 15 deg (estimated)

* + - * Post-impact Trajectory

Vehicle Stability Satisfactory

Stopping Distance 25 ft (78.6 m) downstream

9.8 ft (3.0 m) laterally behind

* + - * Vehicle Snagging None
      * Vehicle Pocketing None
      * Occupant Impact Velocity

Longitudinal 16.99 ft/s (5.18 m/s) < 39.4 ft/s (12 m/s)

* + - * Lateral (not required) 17.29 ft/s (5.27 m/s) < 39.4 ft/s (12 m/s)
      * Occupant Ridedown Deceleration (10 msec avg.)

Longitudinal 7.17 < 20 G

Lateral (not required) 11.37 G

* + - * THIV 22.60 ft/s (6.89 m/s)
      * PHD 11.52 G
      * Test Article Damage Moderate
      * Test Article Deflections

Permanent Set 73 in. (1854 mm)

Dynamic 80 in. (2023 mm)

Working Width 102 in. (2595 mm)

* + - * Vehicle Damage Moderate

VDS 11-LFQ-3

CDC 11-LYES4

Maximum Deformation 4.25 in. (108 mm) at front floor pan

Figure 6-2. Example of Recommended Summary Sheet for Crash Test Result