U.S. Department
of Transportation
Federal Highway Administration

1200 New Jersey Ave., SE
Washington, D.C. 20590

SEP 17 2018

In Reply Refer To:
HSST-1 / CC-145

Mr. Charles Mettler
Plastic Safety Systems, Inc.
2444 Baldwin Road
Cleveland, Ohio 44104

Dear Mr. Mettler:

This letter is in response to your June 25, 2018 request for the Federal Highway Administration (FHWA) to review a roadside safety device, hardware, or system for eligibility for reimbursement under the Federal-aid highway program. This FHWA letter of eligibility is assigned FHWA control number CC-145 and is valid until a subsequent letter is issued by FHWA that expressly references this device.

Decision

The following device is eligible within the length-of-need, with details provided in the form which is attached as an integral part of this letter:

- CrashGard®

Scope of this Letter

To be found eligible for Federal-aid funding, new roadside safety devices should meet the crash test and evaluation criteria contained in the American Association of State Highway and Transportation Officials' (AASHTO) Manual for Assessing Safety Hardware (MASH). However, the FHWA, the Department of Transportation, and the United States Government do not regulate the manufacture of roadside safety devices. Eligibility for reimbursement under the Federal-aid highway program does not establish approval, certification or endorsement of the device for any particular purpose or use.

This letter is not a determination by the FHWA, the Department of Transportation, or the United States Government that a vehicle crash involving the device will result in any particular outcome, nor is it a guarantee of the in-service performance of this device. Proper manufacturing, installation, and maintenance are required in order for this device to function as tested.

This finding of eligibility is limited to the crashworthiness of the system and does not cover other structural features, nor conformity with the Manual on Uniform Traffic Control Devices.

Eligibility for Reimbursement

Based solely on a review of crash test results and certifications submitted by the manufacturer, and the crash test laboratory, FHWA agrees that the device described herein meets the crash test and evaluation criteria of the AASHTO's MASH. Therefore, the device is eligible for reimbursement under the Federal-aid highway program if installed under the range of tested conditions.

Name of system: CrashGard®
Type of system: Crash Cushion
Test Level: MASH Test Level 3 (TL3)
Testing conducted by: Texas A&M Transportation Institute
Date of request: June 25, 2018
Date initially acknowledged: June 26, 2018

FHWA concurs with the recommendation of the accredited crash testing laboratory on the attached form.

Full Description of the Eligible Device

The device and supporting documentation, including reports of the crash tests or other testing done, videos of any crash testing, and/or drawings of the device, are described in the attached form.

Notice

This eligibility letter is issued for the subject device as tested. Modifications made to the device are not covered by this letter. Any modifications to this device should be submitted to the user (i.e., state DOT) as per their requirements.

You are expected to supply potential users with sufficient information on design, installation and maintenance requirements to ensure proper performance.

You are expected to certify to potential users that the hardware furnished has the same chemistry, mechanical properties, and geometry as that submitted for review, and that it will meet the test and evaluation criteria of AASHTO's MASH.

Issuance of this letter does not convey property rights of any sort or any exclusive privilege. This letter is based on the premise that information and reports submitted by you are accurate and correct. We reserve the right to modify or revoke this letter if: (1) there are any inaccuracies in the information submitted in support of your request for this letter, (2) the qualification testing was flawed, (3) in-service performance or other information reveals safety problems, (4) the system is significantly different from the version that was crash tested, or (5) any other information indicates that the letter was issued in error or otherwise does not reflect full and complete information about the crashworthiness of the system.

Standard Provisions

- To prevent misunderstanding by others, this letter of eligibility designated as FHWA control number CC-145 shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed upon request.

- This letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder.

- This FHWA eligibility letter is not an expression of any Agency view, position, or determination of validity, scope, or ownership of any intellectual property rights to a specific device or design. Further, this letter does not impute any distribution or licensing rights to the requester. This FHWA eligibility letter determination is made based solely on the crash-testing information submitted by the requester. The FHWA reserves the right to review and revoke an earlier eligibility determination after receipt of subsequent information related to crash testing.

- If the subject device is a patented product it may be considered to be proprietary. If proprietary systems are specified by a highway agency for use on Federal-aid projects: (a) they must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that they are essential for synchronization with the existing highway facilities or that no equally suitable alternative exists; or (c) they must be used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes. Our regulations concerning proprietary products are contained in Title 23, Code of Federal Regulations, Section 635.411.

Sincerely,

Michael S. Griffith

Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter	Date of Request:	June 12, 2018	◉ New ○ Resubmission
	Name:	Chuck Mettler	
	Company:	PSS (Plastic Safety Systems) Inc.	
	Address:	2444 Baldwin Road, Cleveland, Ohio 44104	
	Country:	USA	
	To:	Michael S. Griffith, Director FHWA, Office of Safety Technologies	

I request the following devices be considered eligible for reimbursement under the Federal-aid highway program.

Device & Testing Criterion - Enter from right to left starting with Test Level

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'CC': Crash Cushions, Attenuators, & Terminals	◉ Physical Crash Testing ○ Engineering Analysis	CrashGard®	AASHTO MASH	TL3

By submitting this request for review and evaluation by the Federal Highway Administration, I certify that the product(s) was (were) tested in conformity with the AASHTO Manual for Assessing Safety Hardware and that the evaluation results meet the appropriate evaluation criteria in the MASH.

Individual or Organization responsible for the product:

Contact Name:	Chuck Mettler	Same as Submitter ☒
Company Name:	PSS (Plastic Safety Systems) Inc.	Same as Submitter ☒
Address:	2444 Baldwin Road, Cleveland, Ohio 44104	Same as Submitter ☒
Country:	USA	Same as Submitter ☒
Enter below all disclosures of financial interests as required by the FHWA 'Federal-Aid Reimbursement Eligibility Process for Safety Hardware Devices' document.		
None		

PRODUCT DESCRIPTION

(•) New Hardware or Significant Modification ( ) Modification to Existing Hardware

The installation consisted of an array of 12 PSS CrashGard® sand barrels, each 36 inches in diameter at the top × 48 inches tall (approximately 36½ diameter × 53 inches with a lid). The 12 barrels were positioned in a combined pattern of two barrels wide by four barrels deep behind a single column of four barrels (see Appendix A of attached report). The barrels were spaced approximately 6 inches apart in all directions. Overall width of the installation was approximately 6 ft-7 inches, and overall depth was approximately 27 ft 2 1/2 inches. The barrels were set on a clean, dry concrete apron without adhesives, anchorage, or bolting.
Each barrel was filled with washed sand to levels specified by the manufacturer to attain nominal weights of 2100 lb, 1400 lb, 700 lb, 400 lb, and 200 lb. A conical shaped insert was placed in 10 of the barrels prior to placing the sand. The two 2100 lb barrels did not contain this insert. Refer to Appendix A and B of attached report for weight specific locations of the barrels. Each empty barrel, with insert and lid, weighed approximately 52 lb. An empty barrel and lid without an insert weighed approximately 45 lb. The estimated total weight for the 12 barrels with sand was 12,100 lb.

CRASH TESTING

By signature below, the Engineer affiliated with the testing laboratory, agrees in support of this submission that all of the critical and relevant crash tests for this device listed above were conducted to meet the MASH test criteria. The Engineer has determined that no other crash tests are necessary to determine the device meets the MASH criteria.

Engineer Name:	D. Lance Bullard, Jr.	
Engineer Signature:	D. Lance Bullard, Jr. Digitally signed by D. Lance Bullard, Jr. Date: 2018.06.04 08:30:57 -05'00'	
Address:	TTI, TAMU 3135, College Station, TX 77843-3135	Same as Submitter ☐
Country:	USA	Same as Submitter ☐

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-31 (2270P)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-32 (1100C)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-33 (2270P)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-34 (1100C)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-35 (2270P)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-36 (2270P)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-37 (2270P)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted
3-38 (1500A)	The product is not a terminal nor a redirective crash cushion.	Non-Relevant Test, not conducted

Required Test Number	Narrative Description	Evaluation Results
3-40 (1100C)	Test 3-40 involves an 1100C vehicle impacting the test article at a target speed of 62 mph and a target angle of 0 degrees. The results of the test conducted on February 28, 2018 are found in TTI Test Report number 690900-PSS11-16. The test vehicle was traveling at an impact speed of 62.6 mi/h as it contacted the crash cushion with the right quarter point of the vehicle aligned with the centerline of the crash cushion at an impact angle of 0.5°. After loss of contact with the crash cushion, the vehicle came to rest 15 ft downstream of the point of impact and 10 ft toward the traffic side (left). The last two barrels set nearest the backstop of the array remained upright, however, the barrels were damaged and the lids were missing. The remaining barrels in the array were deformed and lying on the ground surface, and sand from these barrels was strewn about the test site. Debris scatter was 47 ft downstream × 15 ft left and 29 ft right. The front bumper, hood, and right and left front fenders were damaged. The windshield sustained a stress crack radiating from the right lower corner of the windshield. Maximum exterior crush to the vehicle was 7.5 inches in the front plane just above bumper height. No occupant compartment deformation or intrusion was noted. Occupant risk factors were all within the preferred MASH limits. The device performed acceptably for MASH test 3-40.	PASS

3-41 (2270P)	Test 3-41 involves a 2270P vehicle impacting the test article at a target speed of 62 mph and a target angle of 0 degrees. The results of the test conducted on March 1, 2018 are found in TTI Test Report number 690900-PSS11-16. The test vehicle was traveling at an impact speed of 63.7 mi/h as it contacted the crash cushion at an impact angle of 0.4°. After loss of contact with the barrier, the vehicle came to rest 24 ft downstream of the impact. Barrels #1, #2, #3, #4, and #12 (see attached report) were crushed between the vehicle and the backup structure. The remaining barrels were deformed and the barrels, lids, and sand were strewn about the test area. Maximum debris scatter was 113 ft downstream × 38 ft right and 25 ft left. The front bumper, grill, hood, and radiator and support were deformed. Maximum exterior crush to the vehicle was 17.0 inches in the front plane near the center at bumper height. No occupant compartment deformation or intrusion was noted. Occupant risk factors were all within the preferred MASH limits. The device performed acceptably for MASH test 3-41.	PASS
3-42 (1100C)	Test 3-42 involves an 1100C vehicle impacting the test article at a target speed of 62 mph and a target angle of 5-to-15 degrees. The results of the test conducted on February 28, 2018 are found in TTI Test Report number 690900-PSS11-16. The test vehicle was traveling at an impact speed of 63.0 mi/h as it contacted the crash cushion with the centerline of the front of the vehicle aligned with the centerline of the nose of the crash cushion at an impact angle of 5.5°. After loss of contact with the barrier, the vehicle came to rest 21 ft downstream of the impact and 36 ft toward the field side (right). All barrels were displaced except for barrel #11. A 12-inch tall piece of a barrel was wedged under the front bumper of the vehicle. Debris scatter was 90 ft long × 32 ft right and 35 ft left. The front bumper, hood, grill, radiator and support, and left front fender were deformed. The windshield was cracked in the left lower corner. Maximum exterior crush to the vehicle was 12.0 inches in the front plane at the left front corner just above bumper height. No occupant compartment deformation or intrusion was noted. Occupant risk factors were all within the preferred MASH limits. The device performed acceptably for MASH test 3-42.	PASS

3-43 (2270P)	Test 3-43 involves a 2270P vehicle impacting the test article at a target speed of 62 mph and a target angle of 5-to-15 degrees. The results of the test conducted on March 1, 2018 are found in TTI Test Report number 690900-PSS11-16. The test vehicle was traveling at an impact speed of 62.8 mi/h as it contacted the crash cushion with the centerline of the front of the vehicle with the centerline of the nose of the crash cushion at an impact angle of 5.7°. After loss of contact with the barrier, the vehicle came to rest 45 ft downstream of the impact and 25 ft toward the field side (right). Barrel #11 was undisturbed, and barrel 12 was upright but crushed against the backup structure, and missing the lid and some sand. One barrel was wedged under the front of the test vehicle. The remaining barrels, lids, and sand were strewn about the test area. Maximum extent of debris was 109 ft downstream x 44 ft to the right side and 32 ft to the left side. The front bumper, grill, hood, and radiator and support were deformed. Maximum exterior crush to the vehicle was 13.0 inches in the front plane at the center at bumper height. No occupant compartment deformation or intrusion was noted. Occupant risk factors were all within the preferred MASH limits. The device performed acceptably for MASH test 3-43.	PASS

3-44 (2270P)	Test 3-44 involves a 2270P vehicle impacting the test article at a target speed of 62 mph and a target angle of 20 degrees. The results of the test conducted on February 16, 2018 are found in TTI Test Report number 690900-PSS11-16. The test vehicle was traveling at an impact speed of 63.0 mi/h as it contacted the crash cushion, with the centerline of the vehicle aligned with the leading traffic side corner of the backup structure at an impact angle of 21.1°. After loss of contact with the barrier, the vehicle came to rest 17 inches upstream of the leading traffic side corner of the backup structure and 11 ft toward traffic lanes (left side). Barrels #1 through #4 were not impacted and remained in place. Barrels # 7 and 9 were split, and barrel #11 was crushed against the backup structure. All remaining barrels were crushed and most of the sand strewn about. Debris scatter was 54 ft downstream x 11 ft left and 40 ft right. The front bumper, radiator and support, hood, grill, water pump and fan, right front fender, and left front fender were damaged. The windshield was also cracked in several locations. Maximum exterior crush to the vehicle was 26.0 inches in the front plane at center bumper height. No occupant compartment deformation or intrusion was noted. The device performed acceptably for MASH test 3-44.	PASS

3-45 (1500A)	Test 3-45 involves a 1500A vehicle impacting the test article at a target speed of 62 mph and a target angle of 0 degrees. The results of the test conducted on February 16, 2018 are found in TTI Test Report number 690900-PSS11-16. The test vehicle was traveling at an impact speed of 63.7 mi/h as it contacted the nose of the crash cushion, with the centerline of the vehicle aligned with the centerline of the crash cushion at an impact angle of 1.0°. After loss of contact with the barrier, the vehicle came to rest 5.5 ft downstream of the impact point on barrel #1 and 2 ft toward traffic lanes (left). Three barrels were split, and the crushed bottoms remained in the impact area. All remaining barrels were deformed and sand was strewn about. The front bumper, hood, grill, radiator and support, and right and left front fenders were deformed. A stress crack radiated from the left lower corner of the windshield, and traveled upward and outward. Maximum exterior crush to the vehicle was 8.0 inches in the front plane at the centerline of the vehicle just above bumper height. No occupant compartment deformation or intrusion was noted. Occupant risk factors were all within the preferred MASH limits. The device performed acceptably for MASH test 3-45.	PASS

Full Scale Crash Testing was done in compliance with MASH by the following accredited crash test laboratory (cite the laboratory's accreditation status as noted in the crash test reports.):

Laboratory Name:	Texas A&M Transportation Institute	
Laboratory Signature:	Darrell L. Kuhn — Digitally signed by Darrell L. Kuhn Date: 2018.06.01 17:05:02 -05'00'	
Address:	TTI, TAMU 3135, College Station, TX 77843-3135	Same as Submitter ☐
Country:	USA	Same as Submitter ☐
Accreditation Certificate Number and Dates of current Accreditation period :	ISO 17025 Laboratory Certificate Number: 2821.01 Valid To: April 30, 2019	

Submitter Signature*:

Submit Form

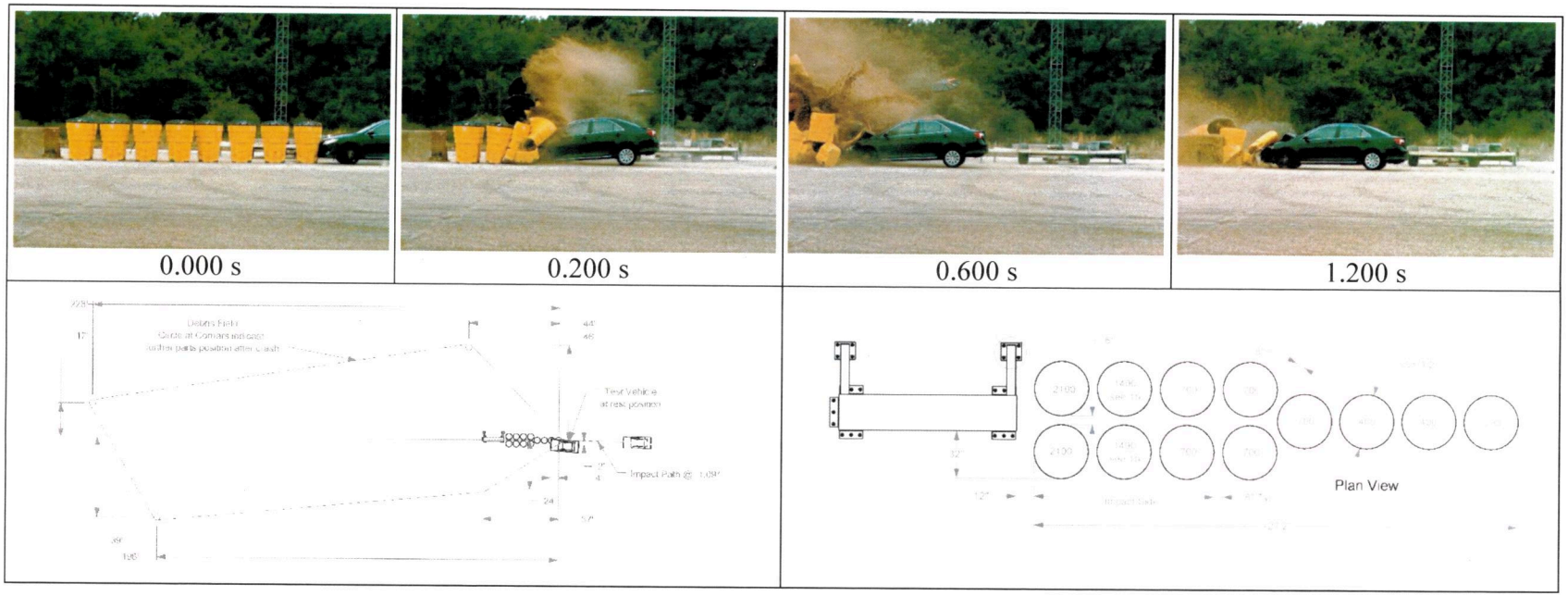
ATTACHMENTS

Attach to this form:

1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [Hardware Guide Drawing Standards]. For proprietary products, a single isometric line drawing is usually acceptable to illustrate the product, with detailed specifications, intended use, and contact information provided on the reverse. Additional drawings (not in TF-13 format) showing details that are relevant to understanding the dimensions and performance of the device should also be submitted to facilitate our review.

FHWA Official Business Only:

Eligibility Letter		
Number	Date	Key Words



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-45
- TTI Test No. 690900-PSS12
- Test Date 2018-02-16

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 1500A
- Make and Model ..... 2012 Toyota Camry
- Curb ..... 3099 lb
- Test Inertial ..... 3309 lb
- Dummy ..... No dummy
- Gross Static ..... 3309 lb

Impact Conditions
- Speed ..... 63.7 mi/h
- Angle ..... 1.0°
- Location/Orientation ..... Nose–centerline to centerline of device

Impact Severity ..... 449 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 5.8°

Occupant Risk Values
- Longitudinal OIV ..... 24.9 ft/s
- Lateral OIV ..... 0.3 ft/s
- Longitudinal Ridedown ..... 8.1 g
- Lateral Ridedown ..... 1.2 g
- THIV ..... 27.2 km/h
- PHD ..... 8.1 g
- ASI 0.59

Max. 0.050-s Average
- Longitudinal ..... -6.9 g
- Lateral ..... -0.7 g
- Vertical ..... 2.0 g

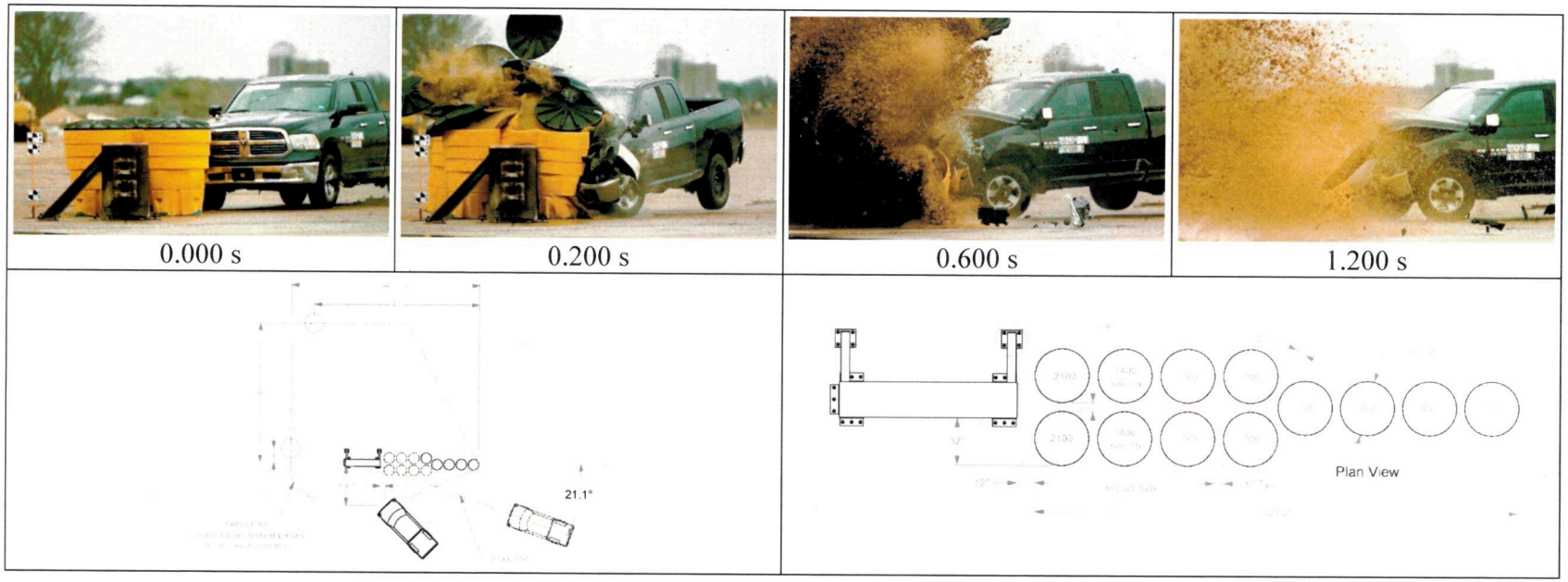
Post-Impact Trajectory
- Stopping Distance ..... 5.5 ft upstream 2.0 ft left

Vehicle Stability
- Maximum Yaw Angle ..... 10°
- Maximum Pitch Angle ..... 6°
- Maximum Roll Angle ..... 5°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage
- VDS 12FD5
- CDC 12FDEW4
- Max. Exterior Deformation ..... 8.0 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 10.7. Summary of Results for *MASH* Test 3-45 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-44
- TTI Test No. 690900-PSS11
- Test Date 2018-02-16

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 2270P
- Make and Model ..... 2013 Dodge RAM 1500 Pickup
- Curb ..... 5028 lb
- Test Inertial ..... 5029 lb
- Dummy ..... No dummy
- Gross Static ..... 5029 lb

Impact Conditions
- Speed ..... 63.0 mi/h
- Angle ..... 21.1°
- Location/Orientation ..... Center of vehicle w/leading corner of backup structure

Kinetic Energy ..... 667 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 46°

Occupant Risk Values
- Longitudinal OIV ..... 34.4 ft/s
- Lateral OIV ..... 3.3 ft/s
- Longitudinal Ridedown ..... 20.4 g
- Lateral Ridedown ..... 3.4 g
- THIV ..... 38.0 km/h
- PHD ..... 20.5 g
- ASI 1.49

Max. 0.050-s Average
- Longitudinal ..... -17.3 g
- Lateral ..... -2.5 g
- Vertical ..... -4.5 g

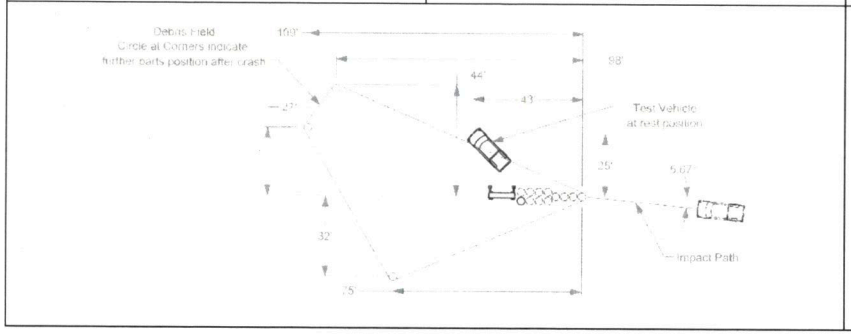
Post-Impact Trajectory
- Stopping Distance ..... 17 inches upstream 11 ft left

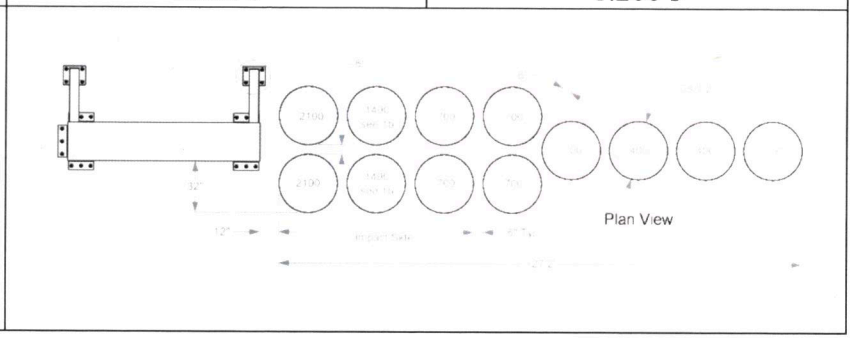
Vehicle Stability
- Maximum Yaw Angle ..... 39°
- Maximum Pitch Angle ..... 5°
- Maximum Roll Angle ..... 17°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter
- Height of Working Width ..... NA

Vehicle Damage
- VDS 12FD6
- CDC 12FDEW5
- Max. Exterior Deformation ..... 26.0 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 9.7. Summary of Results for *MASH* Test 3-44 on CrashGard® Sand Barrel System.





General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-43
- TTI Test No. 690900-PSS15
- Test Date 2018-03-01

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 2270P
- Make and Model ..... 2013 Dodge RAM 1500 Pickup
- Curb ..... 4988 lb
- Test Inertial ..... 5042 lb
- Dummy ..... No dummy
- Gross Static ..... 5042 lb

Impact Conditions
- Speed ..... 62.8 mi/h
- Angle ..... 5.7°
- Location/Orientation ..... Nose – centerline to centerline

Kinetic Energy ..... 665 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 39.3°

Occupant Risk Values
- Longitudinal OIV ..... 24.9 ft/s
- Lateral OIV ..... 1.0 ft/s
- Longitudinal Ridedown ..... 11.0 g
- Lateral Ridedown ..... 2.0 g
- THIV ..... 27.2 km/h
- PHD ..... 11.0 g
- ASI 0.77

Max. 0.050-s Average
- Longitudinal ..... -9.0 g
- Lateral ..... 1.8 g
- Vertical ..... -4.4 g

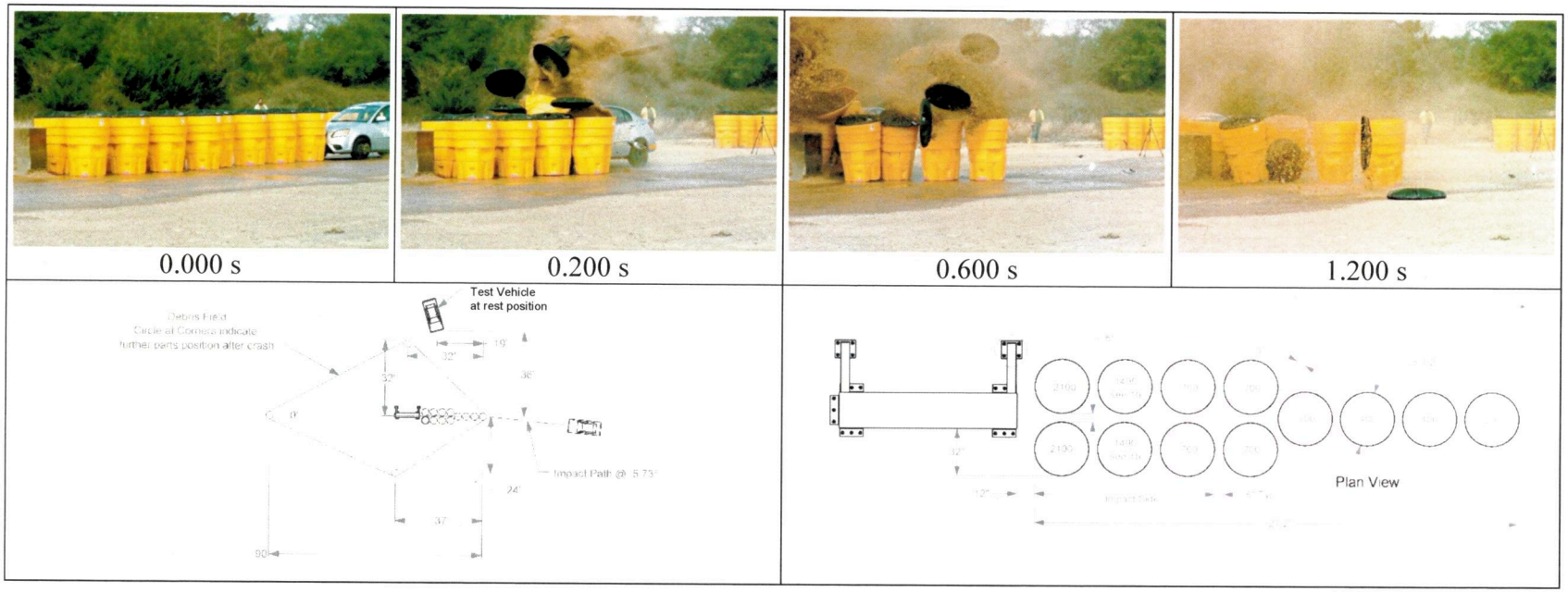
Post-Impact Trajectory
- Stopping Distance ..... 45 ft downstream 25 ft right

Vehicle Stability
- Maximum Yaw Angle ..... 36°
- Maximum Pitch Angle ..... 12°
- Maximum Roll Angle ..... 11°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage
- VDS 12FC3
- CDC 12FCEN3
- Max. Exterior Deformation ..... 13.0 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 8.6. Summary of Results for *MASH* Test 3-43 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-42
- TTI Test No. 690900-PSS16
- Test Date 2018-02-28

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 1100C
- Make and Model ..... 2010 Kia Rio
- Curb ..... 2460 lb
- Test Inertial ..... 2454 lb
- Dummy ..... 165 lb
- Gross Static ..... 2619 lb

Impact Conditions
- Speed ..... 63.0 mi/h
- Angle ..... 5.5°
- Location/Orientation ..... Nose – centerline to centerline

Kinetic Energy ..... 326 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 106° CCW

Occupant Risk Values
- Longitudinal OIV ..... 25.9 ft/s
- Lateral OIV ..... 2.3 ft/s
- Longitudinal Ridedown ..... 7.7 g
- Lateral Ridedown ..... 3.8 g
- THIV ..... 28.8 km/h
- PHD ..... 7.7 g
- ASI 0.60

Max. 0.050-s Average
- Longitudinal ..... -6.9 g
- Lateral ..... -1.2 g
- Vertical ..... 2.0 g

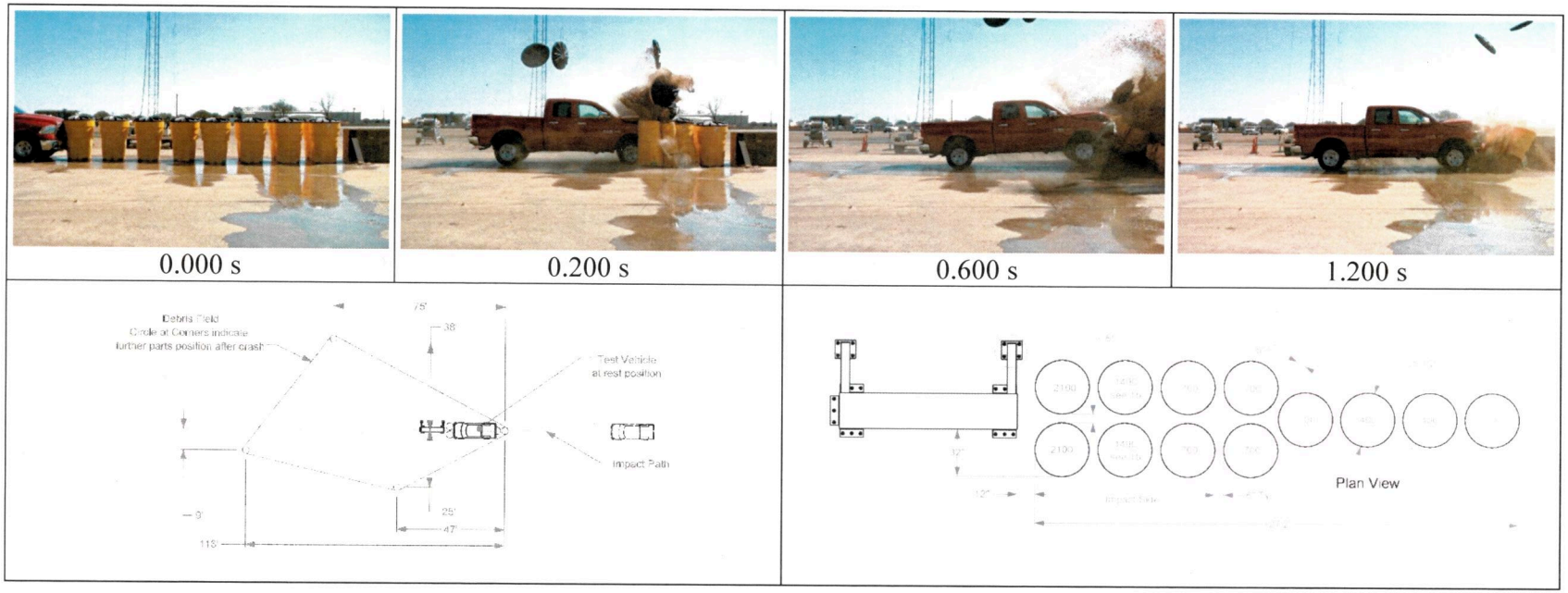
Post-Impact Trajectory
- Stopping Distance ..... 21 ft downstream 36 ft right

Vehicle Stability
- Maximum Yaw Angle ..... 106°
- Maximum Pitch Angle ..... 5°
- Maximum Roll Angle ..... 4°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage
- VDS 12FD4
- CDC 12FDEW3
- Max. Exterior Deformation ..... 12.0 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 7.6. Summary of Results for *MASH* Test 3-42 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-41
- TTI Test No. 690900-PSS14
- Test Date 2018-03-01

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall
- **Soil Type and Condition** ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 2270P
- Make and Model ..... 2014 Dodge RAM 1500 Pickup
- Curb ..... 5122 lb
- Test Inertial ..... 5026 lb
- Dummy ..... No dummy
- Gross Static ..... 5026 lb

Impact Conditions
- Speed ..... 63.7 mi/h
- Angle ..... 0.4°
- Location/Orientation ..... Nose – center to center
- **Kinetic Energy** ..... 682 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 2.0°

Occupant Risk Values
- Longitudinal OIV ..... 25.9 ft/s
- Lateral OIV ..... 0.3 ft/s
- Longitudinal Ridedown ..... 12.4 g
- Lateral Ridedown ..... 1.1 g
- THIV ..... 28.4 km/h
- PHD 12.4
- ASI 0.81

Max. 0.050-s Average
- Longitudinal ..... -9.0 g
- Lateral ..... 0.6 g
- Vertical ..... -2.3 g

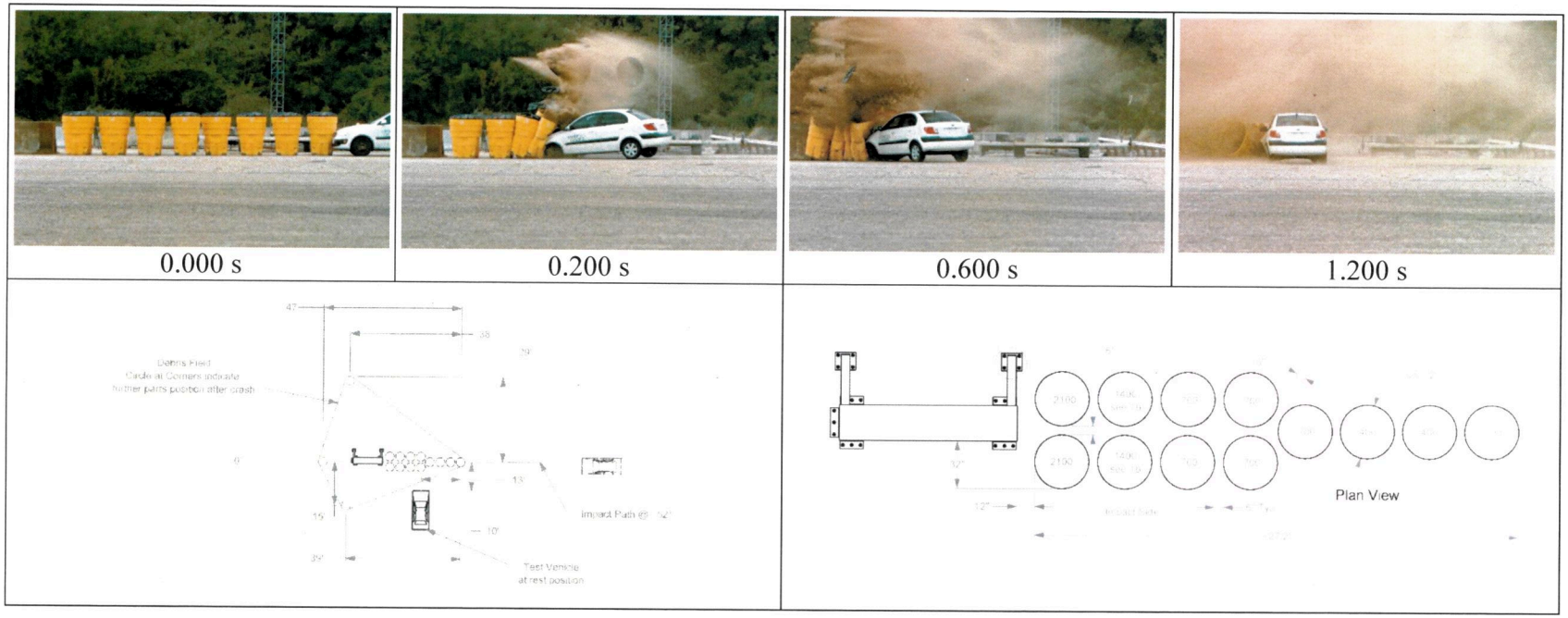
Post-Impact Trajectory
- Stopping Distance ..... 24 ft downstream

Vehicle Stability
- Maximum Yaw Angle ..... 5°
- Maximum Pitch Angle ..... 5°
- Maximum Roll Angle ..... 4°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage 12FC3
- VDS 12FCEN3
- CDC ..... 17.0 inches
- Max. Exterior Deformation FS0000000
- OCDI .....
- Max. Occupant Compartment Deformation ..... None

Figure 6.6. Summary of Results for *MASH* Test 3-41 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-40
- TTI Test No. 690900-PSS13
- Test Date 2018-02-28

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 1100C
- Make and Model ..... 2009 Kia Rio
- Curb ..... 2491 lb
- Test Inertial ..... 2431 lb
- Dummy ..... 165 lb
- Gross Static ..... 2596 lb

Impact Conditions
- Speed ..... 62.6 mi/h
- Angle ..... 0.5°
- Location/Orientation ..... Nose – Qtr Point

Impact Severity ..... 318 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 89°

Occupant Risk Values
- Longitudinal OIV ..... 28.9 ft/s
- Lateral OIV 0
- Longitudinal Ridedown ..... 9.0 g
- Lateral Ridedown ..... 2.9 g
- THIV ..... 32.1 km/h
- PHD ..... 9.0 g
- ASI 0.67

Max. 0.050-s Average
- Longitudinal ..... -7.6 g
- Lateral ..... 1.5 g
- Vertical ..... 2.6 g

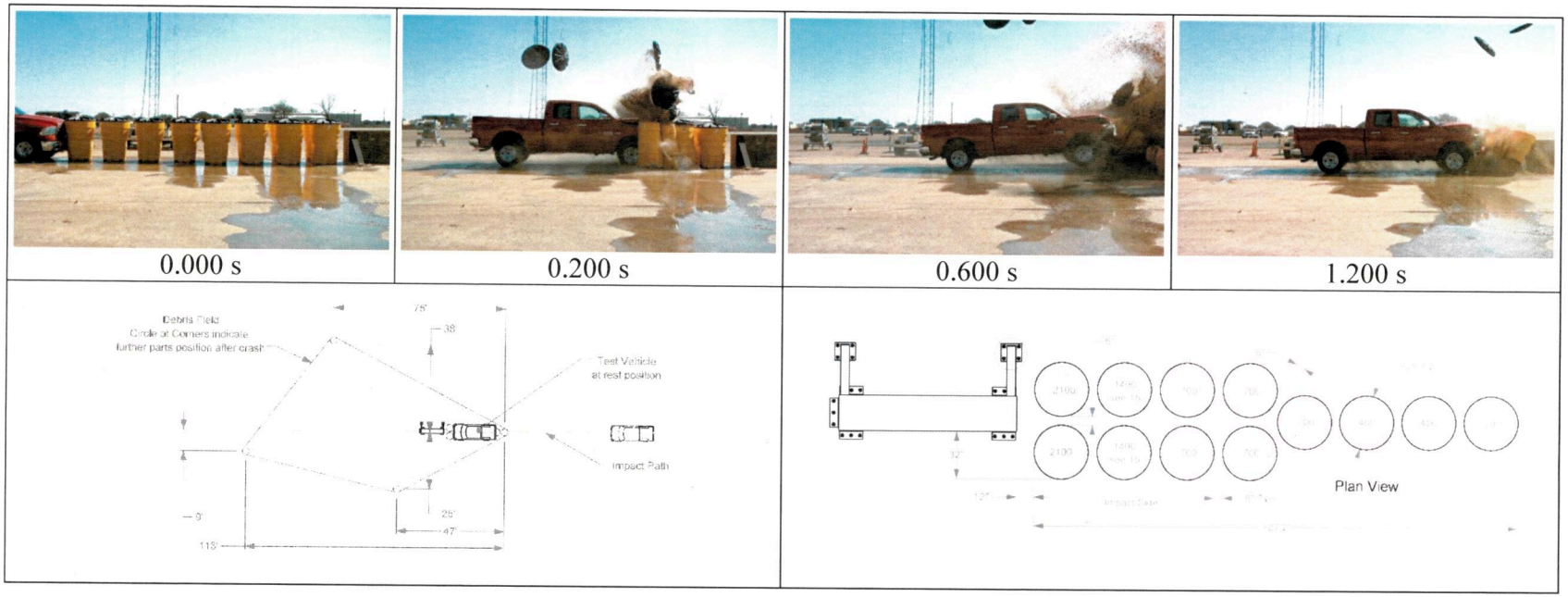
Post-Impact Trajectory
- Stopping Distance ..... 15 ft downstream 10 ft left

Vehicle Stability
- Maximum Yaw Angle ..... 92°
- Maximum Pitch Angle ..... 3°
- Maximum Roll Angle ..... 5°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage
- VDS 12FD3
- CDC 12FDEW3
- Max. Exterior Deformation ..... 7.5 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 5.6. Summary of Results for *MASH* Test 3-40 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-41
- TTI Test No. 690900-PSS14
- Test Date 2018-03-01

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 2270P
- Make and Model ..... 2014 Dodge RAM 1500 Pickup
- Curb ..... 5122 lb
- Test Inertial ..... 5026 lb
- Dummy ..... No dummy
- Gross Static ..... 5026 lb

Impact Conditions
- Speed ..... 63.7 mi/h
- Angle ..... 0.4°
- Location/Orientation ..... Nose – center to center

Kinetic Energy ..... 682 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 2.0°

Occupant Risk Values
- Longitudinal OIV ..... 25.9 ft/s
- Lateral OIV ..... 0.3 ft/s
- Longitudinal Ridedown ..... 12.4 g
- Lateral Ridedown ..... 1.1 g
- THIV ..... 28.4 km/h
- PHD 12.4
- ASI 0.81

Max. 0.050-s Average
- Longitudinal ..... -9.0 g
- Lateral ..... 0.6 g
- Vertical ..... -2.3 g

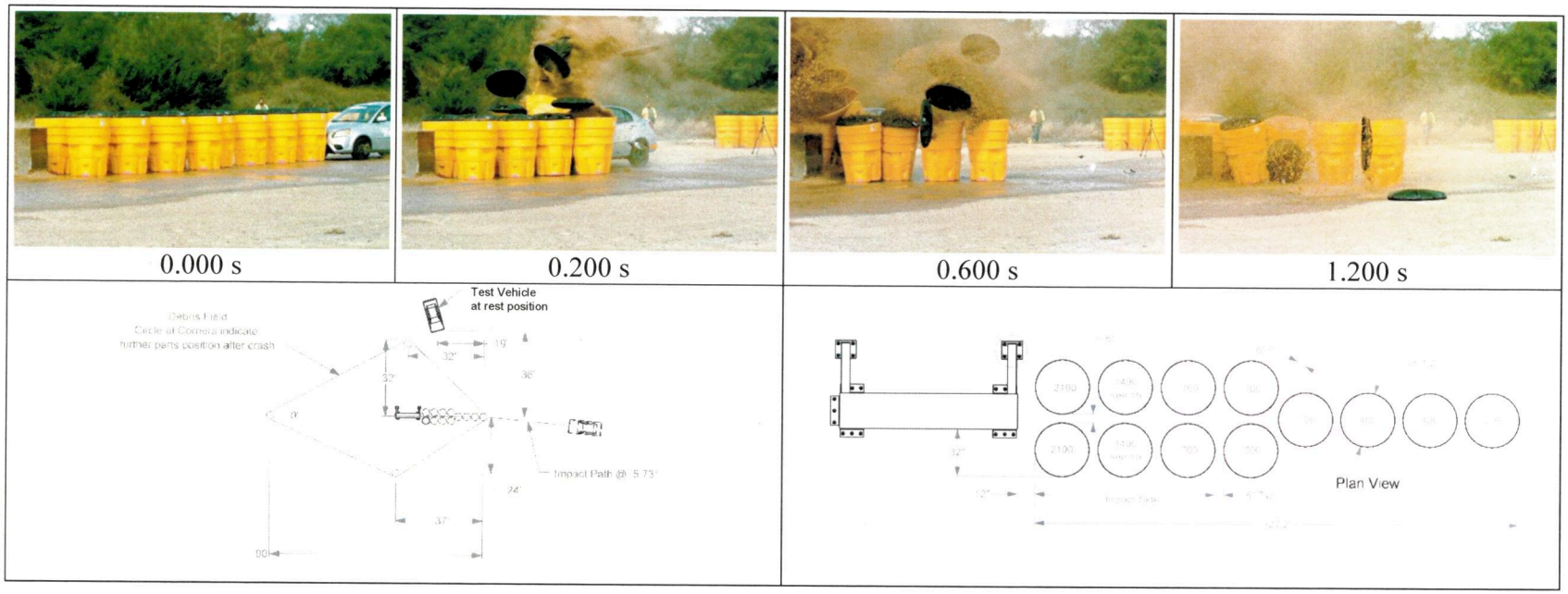
Post-Impact Trajectory
- Stopping Distance ..... 24 ft downstream

Vehicle Stability
- Maximum Yaw Angle ..... 5°
- Maximum Pitch Angle ..... 5°
- Maximum Roll Angle ..... 4°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage 12FC3
- VDS 12FCEN3
- CDC ..... 17.0 inches
- Max. Exterior Deformation FS0000000
- OCDI .....
- Max. Occupant Compartment Deformation ..... None

Figure 6.6. Summary of Results for *MASH* Test 3-41 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-42
- TTI Test No. 690900-PSS16
- Test Date 2018-02-28

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 1100C
- Make and Model ..... 2010 Kia Rio
- Curb ..... 2460 lb
- Test Inertial ..... 2454 lb
- Dummy ..... 165 lb
- Gross Static ..... 2619 lb

Impact Conditions
- Speed ..... 63.0 mi/h
- Angle ..... 5.5°
- Location/Orientation ..... Nose – centerline to centerline

Kinetic Energy ..... 326 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 106° CCW

Occupant Risk Values
- Longitudinal OIV ..... 25.9 ft/s
- Lateral OIV ..... 2.3 ft/s
- Longitudinal Ridedown ..... 7.7 g
- Lateral Ridedown ..... 3.8 g
- THIV ..... 28.8 km/h
- PHD ..... 7.7 g
- ASI 0.60

Max. 0.050-s Average
- Longitudinal ..... -6.9 g
- Lateral ..... -1.2 g
- Vertical ..... 2.0 g

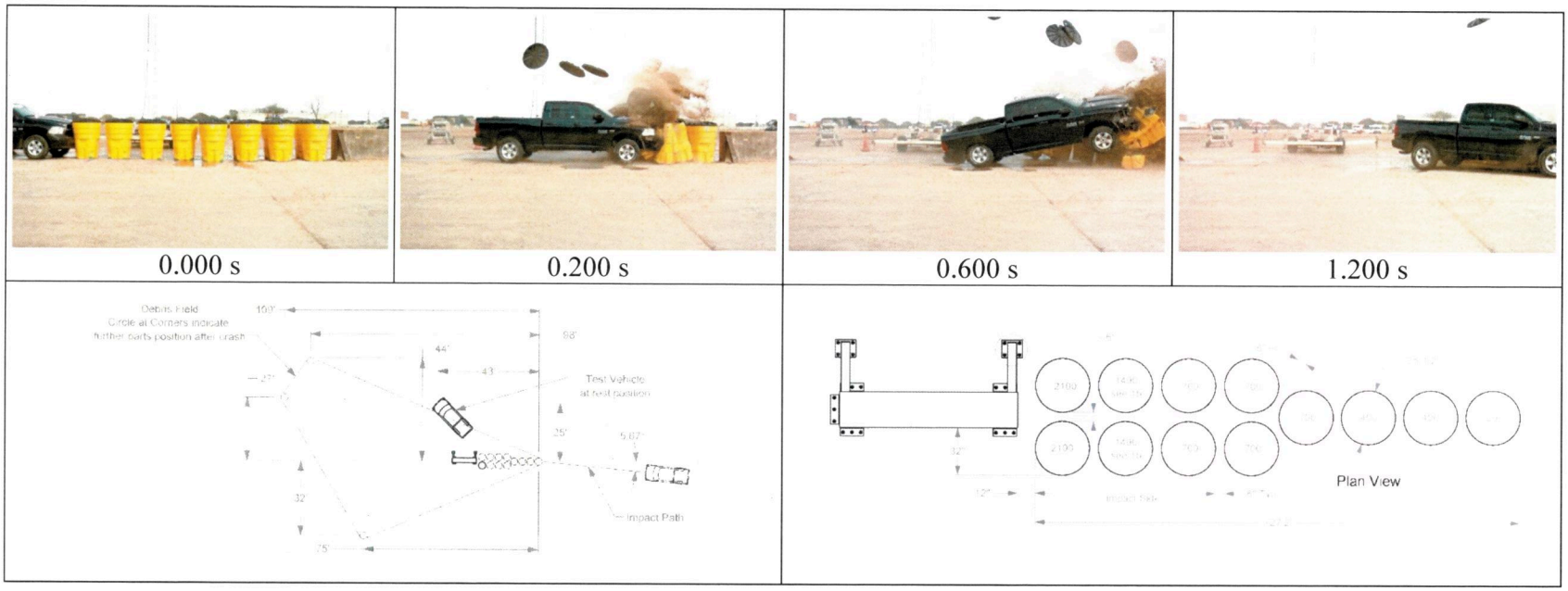
Post-Impact Trajectory
- Stopping Distance ..... 21 ft downstream 36 ft right

Vehicle Stability
- Maximum Yaw Angle ..... 106°
- Maximum Pitch Angle ..... 5°
- Maximum Roll Angle ..... 4°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage
- VDS 12FD4
- CDC 12FDEW3
- Max. Exterior Deformation ..... 12.0 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 7.6. Summary of Results for *MASH* Test 3-42 on CrashGard® Sand Barrel System.



General Information
- Test Agency ..... Texas A&M Transportation Institute (TTI)
- Test Standard Test No. ..... MASH Test 3-43
- TTI Test No. 690900-PSS15
- Test Date 2018-03-01

Test Article
- Type ..... Non-Redirective Crash Cushion
- Name ..... CrashGard® Sand Barrel System
- Installation Dimensions ..... Width 6 ft-7 inches, Depth 27 ft-2½ inches
- Material or Key Elements ... 12 proprietary PSS CrashGard® sand barrels, each approximately Ø36-1/2 inches at the top × 53 inches tall

Soil Type and Condition ..... Placed on concrete surface, damp

Test Vehicle
- Type/Designation 2270P
- Make and Model ..... 2013 Dodge RAM 1500 Pickup
- Curb ..... 4988 lb
- Test Inertial ..... 5042 lb
- Dummy ..... No dummy
- Gross Static ..... 5042 lb

Impact Conditions
- Speed ..... 62.8 mi/h
- Angle ..... 5.7°
- Location/Orientation ..... Nose – centerline to centerline

Kinetic Energy ..... 665 kip-ft

Exit Conditions
- Speed ..... Stopped
- Angle ..... 39.3°

Occupant Risk Values
- Longitudinal OIV ..... 24.9 ft/s
- Lateral OIV ..... 1.0 ft/s
- Longitudinal Ridedown ..... 11.0 g
- Lateral Ridedown ..... 2.0 g
- THIV ..... 27.2 km/h
- PHD ..... 11.0 g
- ASI 0.77

Max. 0.050-s Average
- Longitudinal ..... -9.0 g
- Lateral ..... 1.8 g
- Vertical ..... -4.4 g

Post-Impact Trajectory
- Stopping Distance ..... 45 ft downstream 25 ft right

Vehicle Stability
- Maximum Yaw Angle ..... 36°
- Maximum Pitch Angle ..... 12°
- Maximum Roll Angle ..... 11°

Test Article Deflections
- Dynamic ..... See Drawing Above
- Permanent ..... for Details of Debris
- Working Width ..... Scatter

Vehicle Damage
- VDS 12FC3
- CDC 12FCEN3
- Max. Exterior Deformation ..... 13.0 inches
- OCDI FS0000000
- Max. Occupant Compartment Deformation ..... None

Figure 8.6. Summary of Results for *MASH* Test 3-43 on CrashGard® Sand Barrel System.

APPENDIX A. DETAILS OF THE TEST ARTICLE