U.S. Department of Transportation
Federal Highway Administration

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

March 8, 2018

In Reply Refer To:
HSST-1/CC-139

Mr. Felipe Almanza
TrafFix Devices Inc.
160 Avenida La Pata
San Clemente, CA 92672

Dear Mr. Almanza:

This letter is in response to your September 14, 2017 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-139 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:

- Big Sandy MASH

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: Big Sandy MASH
Type of system: Crash Cushion
Test Level: MASH Test Level 3 (TL3)
Testing conducted by: KARCO
Date of request: September 14, 2017
Date initially acknowledged: September 20, 2017

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 and will need to be tested in accordance with all recommended tests in AASHTO's MASH as part of a new and separate submittal.

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-139 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.

- 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
Director, Office of Safety Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter	Date of Request:	March 01, 2018	◉ New ○ Resubmission
	Name:	Felipe Almanza	
	Company:	TrafFix Devices Inc.	
	Address:	160 Avenida La Pata San Clemente California 92672	
	Country:	United States	
	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	Big Sandy MASH	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:	Felipe Almanza	Same as Submitter ☒
Company Name:	TrafFix Devices Inc.	Same as Submitter ☒
Address:	160 Avenida La Pata San Clemente California 92672	Same as Submitter ☒
Country:	United States	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.		
TrafFix Devices Inc. and Karco Engineering LLC share no financial interests between the two organizations. This includes no shared financial interest but not limited to: i. Compensation including wages, salaries, commissions, professional fees, or fees for business referrals iii. Research funding or other forms of research support; iv. Patents, copyrights, licenses, and other intellectual property interests; vi. Business ownership and investment interests;		

PRODUCT DESCRIPTION

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

The Big Sandy Inertial Crash Cushion System is a non-redirective, gating crash cushion, designed to shield the end of rigid objects in both temporary and/or permanent roadside installations. The Big Sandy consists of an array of individual free-standing plastic sand filled barrels in consecutive rows which contain gradually increasing weights of sand within the array. The Big Sandy Barrels are not anchored to the road surface and do not require a transition to the barrier it is shielding. The Big Sandy can be used on concrete, asphalt, gravel, compacted dirt, and inertial (barrel/module) pallets. The test series was conducted shielding freestanding barrier and fixed anchored barrier on a concrete surface.

The Big Sandy barrels come in three configurations 2100 lb. (960 kg) barrels with an overall height of 52.5 in. (1333.5mm), 1400 lb. (640 kg) barrels with an overall height of 40.75 in. (1035mm), and a two-piece combo barrel consisting of a pedestal base, and an upper canister. When assembled, the hour glass shaped combo barrel has a height of 40.3 in. (1024mm). Combo barrels have three molded in marks designating three weight demarcation fill levels. The bottom mark designates a fill level of 200 lbs. (90kg) of sand. The middle mark designates 400 lbs. (180kg) of sand. The top mark designates 700 lbs. (320 kg) of sand. All Big Sandy barrels utilize the same 37 in (940 mm) diameter snap on lid.

The Big Sandy Barrel is manufactured from frangible plastic that is designed to break up into fragments upon impact thereby dispersing the sand contained within each barrel. As the vehicle intrudes into the array a series of collisions occur between the impacting vehicle and the consecutive rows of barrels which contain gradually increasing weights of sand. Each collision gradually reduces the velocity of the impacting vehicle until it is brought to a controlled stop. Due to the nature of the frangible plastic material used in the Big Sandy Barrels, it is not recommended that frangible barrels be intermixed with non-frangible barrels within an array.

The Big Sandy barrels used for TL-3 MASH testing are identical and unchanged from the Big Sandy barrels that have passed NCHRP Report 350 testing (Reference Letter HNG-14 and CC-52A-C). The Big Sandy ICS 12 barrel array used for TL-3 MASH testing is identical to the Big Sandy 12 barrel array that passed NCHRP Report 350 testing. Because the barrels and arrays are the same, Big Sandy barrels and arrays produced since 1998 are now MASH compliant and interchangeable.

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:	Robert Ramirez	
Engineer Signature:	Robert Ramirez — Digitally signed by Robert Ramirez DN: cn=Robert Ramirez, o=KARCO Engineering, ou=Project Engineer, email=rramirez@karco.com, c=US Date: 2018.03.01 17:17:35 -08'00'	
Address:		Same as Submitter ☐
Country:		Same as Submitter ☐

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-31 (2270P)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted

Required Test Number	Narrative Description	Evaluation Results
3-32 (1100C)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-33 (2270P)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-34 (1100C)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-35 (2270P)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-36 (2270P)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-37 (2270P)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-38 (1500A)	Not applicable for non-redirective crash cushion	Non-Relevant Test, not conducted
3-40 (1100C)	The Big Sandy Array was positioned offset a quarter of the vehicle's width toward the passenger side. The offset position examines the risk of exceeding occupant risk values, vehicle instability, and vehicle yaw movement. The test was conducted using a commercially available 2013 Kia Rio 4-door sedan with a test inertial mass of 2464.7 lbs (1118.0 kg). The vehicle was in good condition, was free of major body damage, and was not missing any structural components. The bumpers were standard equipment and were not modified for this test. Based on CarFax reporting there was no recorded history of major accidents, was not a salvage titled vehicle, not involved in flooding, or fire. The test vehicle impacted the front 200 lb (90 kg) combo barrel in the array at a velocity of 63.11 mph (101.57 km/hr) and at an impact angle of 0.5° resulting in the barrel fracturing into pieces and dispersing the contained sand. As the test vehicle intruded further into the array the sand barrels that came into contact with the vehicle fractured into pieces and dispersed the contained sand. The vehicle rotated about its yaw axis before coming to a controlled stop 66.3 ft (20.2 m) forward and 55.3 ft (16.9 m) to the left of the initial impact point. The vehicle remained upright throughout the impact event. The test vehicle's occupant compartment was not penetrated and measurable in cab deformation was deemed acceptable. The maximum roll and pitch angle did not exceed 75° and occupant risk values were within limits per MASH specifications for Occupant Impact Velocity (OIV) and Ridedown Acceleration (RA).	PASS

3-41 (2270P)	The Big Sandy Array was positioned inline with the center of the test vehicle. The inline centered position examines the risk of exceeding occupant risk values, vehicle instability, the system's capacity to absorb sufficient impact energy and the Big Sandy's ability to bring the vehicle to a safe controlled stop. The test was conducted using a commercially available 2012 Dodge Ram 4-door pickup truck with a test inertial mass of 5015.4 lbs (2275.0 kg). The vehicle was in good condition, was free of major body damage, and was not missing any structural components. The bumpers were standard equipment and were not modified for this test. Based on CarFax reporting there was no recorded history of major accidents, was not a salvage titled vehicle, not involved in flooding, or fire. The test vehicle impacted the front 200 lbs (90 kg) combo barrel in the array at a velocity of 62.96 mph (101.32 km/hr) and at an impact angle of 0.1° resulting in the barrel fracturing into pieces and dispersing the contained sand. As the test vehicle intruded further into the array the sand barrels that came into contact with the vehicle fractured into pieces and dispersed the contained sand. The vehicle came to a controlled stop 28.1 ft (8.6 m) forward and 10.3 in (261 mm) to the left of the initial impact. The vehicle remained upright throughout the impact event. The test vehicle's occupant compartment was not penetrated and there was no measurable in cab deformation beyond the allowed limit defined in MASH. The maximum roll and pitch angle did not exceed 75° and occupant risk values are within limits per MASH specifications for Occupant Impact Velocity and Ridedown Acceleration.	PASS

3-42 (1100C)	The Big Sandy Array was positioned at a nominal angle of 5° with the center of the test vehicle. The angle position examines the risk of exceeding occupant risk values, vehicle instability, capacity to absorb sufficient impact energy, and the Big Sandy's ability to bring the vehicle to a safe controlled stop. The test was conducted using a commercially available 2011 Kia Rio 4-door sedan with a test inertial mass of 2401.9 lbs (1089.5 kg). The vehicle was in good condition, was free of major body damage, and was not missing any structural components. The bumpers were standard equipment and were not modified for this test. Based on CarFax reporting there was no recorded history of major accidents, was not a salvage titled vehicle, not involved in flooding, or fire. The test vehicle impacted the front 200 lb (90 kg) combo barrel in the array at a velocity of 66.58 mph (107.15 km/hr) and at an impact angle of 5.2° resulting in the barrel fracturing into pieces and dispersing the contained sand. As the test vehicle intruded further into the array the sand barrels that came into contact with the vehicle fractured into pieces and dispersed the contained sand. The vehicle rotated about its yaw axis before coming to a controlled stop 48.8 ft (14.9 m) forward and 3.6 ft (1.1 m) to the left of the initial impact. The vehicle remained upright throughout the impact event. The test vehicle's occupant compartment was not penetrated and measurable in cab deformation was deemed acceptable. The maximum roll and pitch angle did not exceed 75°. Occupant risk values are within limits per MASH specifications for Occupant Impact Velocity and Ridedown Acceleration.	PASS

3-43 (2270P)	The Big Sandy Array was positioned at a nominal angle of 5° with the center of the test vehicle. The angle position examines the risk of exceeding occupant risk values, vehicle instability, capacity to absorb sufficient impact energy, and the Big Sandy's ability to bring the vehicle to a safe controlled stop. The test was conducted using a commercially available 2012 Dodge Ram 4-door pickup truck with a test inertial mass of 4968.0 lbs (2253.5 kg). The vehicle was in good condition, was free of major body damage, and was not missing any structural components. The bumpers were standard equipment and were not modified for this test. Based on CarFax reporting there was no recorded history of major accidents, was not a salvage titled vehicle, not involved in flooding, or fire. The test vehicle impacted the front 200 lb (90 kg) combo barrel in the array at a velocity of 62.09 mph (99.92 km/hr) and at an impact angle of 5.6 ° resulting in the barrel fracturing into pieces and dispersing the contained sand. As the test vehicle intruded further into the array the sand barrels that came into contact with the vehicle fractured into pieces and dispersed the contained sand. The vehicle rotated about its yaw axis before coming to a controlled stop 128.9 ft (39.3 m) forward and 10.1 ft (3.1 m) to the left of the initial impact. The vehicle remained upright throughout the impact event. The test vehicle's occupant compartment was not penetrated and there were no measurable in cab deformation beyond the allowed limit defined in MASH. The maximum roll and pitch angle did not exceed 75°. Occupant risk values are within limits per MASH specifications for Occupant Impact Velocity and Ridedown Acceleration.	PASS

3-44 (2270P)	The Big Sandy Array was positioned at a nominal angle of 20° and the center line of the impacting vehicle was directed at the corner of the barrier. The vehicle impacted the crash cushion 14.63 ft (4.4 m) from the barrier and 2.44 ft (0.743 m) from the center line of the vehicle. Two 3-44 tests were run. One conducted with freestanding barrier and one with permanently anchored barrier For the test with freestanding barrier (Report TR-P36301) a 2012 Ram 4-door truck was used with an inertial mass of 5004.4 lbs (2270.0 kg), at an impact velocity of 60.32 mph (97.07 km/hr), and at an impact angle of 20.2 °. The vehicle rotated in a clockwise direction about the vertical axis and came to a controlled stop 26.7 ft (8.1 m) forward and 2.4 in (61 mm) from the impact point. For the test with anchored barrier (Report TR-38019) a 2013 Ram 4-door truck was used with an inertial mass of 4995.6 lbs (2266.0 kg), at an impact velocity of 61.26 mph (98.59 km/hr), and at an impact angle of 19.9 °. The vehicle rotated in a clockwise direction about the vertical axis and came to a controlled stop 18.2 ft (5.6 m) forward and 6.2 ft (1.9 m) from the impact point. For both 3-44 tests the truck contacted the first double row of 700 lbs (320 kg) barrels approx. 13.5 ft (4.1 m) from the front of the Big Sandy System. The first impacted barrels fractured dispersing the contained sand. As the vehicle intruded further into the array all the barrels rearward fractured and dispersed the contained sand. The CIP was defined in specifications in MASH for test procedures for Gating Non-Redirective Crash Cushions. The trucks were free of major body damage and based on CarFax there was no recorded history of major accidents. For both tests the truck remained upright, and did not exhibit vaulting. The maximum roll and pitch angle did not exceed 75°. The occupant compartments were not penetrated and there were no measurable in cab deformation beyond the allowed limit defined in MASH.	PASS

3-45 (1500A)	The Big Sandy Array was positioned inline the with center of the test vehicle. The inline centered position examines the risk of exceeding occupant risk values, vehicle instability, capacity to absorb sufficient impact energy, and the Big Sandy's ability to bring the vehicle to a safe controlled stop. The test was conducted using a commercially available 2012 Chevy Malibu 4-door sedan with a test inertial mass of 3284.8 lbs (1490.0 kg). The vehicle was in good condition, was free of major body damage, and was not missing any structural components. The bumpers were standard equipment and were not modified for this test. Based on CarFax reporting there was no recorded history of major accidents, was not a salvage titled vehicle, not involved in flooding, or fire. The test vehicle impacted the front 200 lb (90 kg) combo barrel in the array at a velocity of 61.31 mph (98.67 km/ hr) and at an impact angle of 0.6° resulting in the barrel fracturing into pieces dispersing the contained sand. As the test vehicle intruded further into the array the sand barrels that came into contact with the vehicle fractured into pieces and dispersed the contained sand. The vehicle came to a controlled stop 27.7 ft (8.4 m) forward from the initial impact. The vehicle remained upright throughout the impact event. The test vehicle's occupant compartment was not penetrated and there was no measurable in cab deformation beyond the allowed limit defined in MASH. The maximum roll and pitch angle did not exceed 75° and occupant risk values are within limits per MASH specifications for Occupant Impact Velocity and Ridedown Acceleration.	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:	KARCO Engineering	
Laboratory Signature:	Alex Beltran Digitally signed by Alex Beltran DN: cn=Alex Beltran, o=KARCO Engineering, ou=Testing Laboratory, email=abeltran@karco.com, c=US Date: 2018.03.01 16:53:12 -08'00'	
Address:	9270 Holly Rd. Adelanto CA 92301	Same as Submitter ☐
Country:	United States	Same as Submitter ☐
Accreditation Certificate Number and Dates of current Accreditation period :	October 12, 2017 - July 1, 2018	

Submitter Signature*: Felipe Almanza Digitally signed by Felipe Almanza DN: cn=Felipe Almanza o=TrafFix Devices Inc., ou, email=falmanza@traffixdevices.com, c=US Date: 2018.02.27 16:09:27 -08'00'

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

MASH Test 3-40 Summary

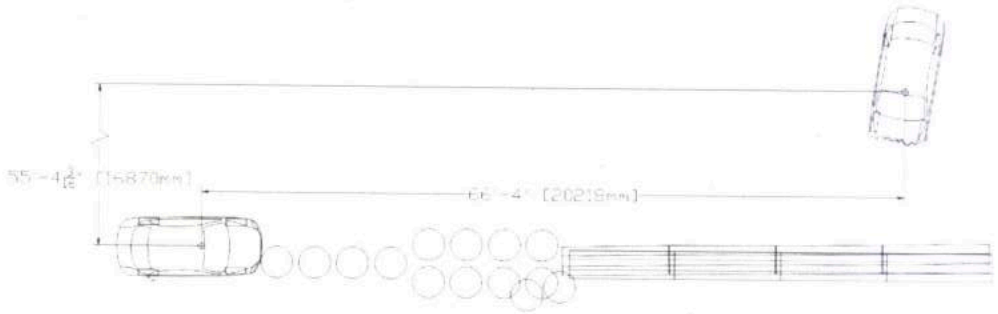
0.000 s

0.100 s

0.300 s

0.500 s

0.900 s



General Information

Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P37027-01
Test Designation	3-40
Test Date	03/06/17

Test Article

Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	49.1 ft (15.0 m)
Road Surface	Concrete

Test Vehicle

Type / Designation	1100C
Year, Make, and Model	2013 Kia Rio
Curb Mass	2,538.6 lbs (1,151.5 kg)
Test Inertial Mass	2,464.7 lbs (1,118.0 kg)
Gross Static Mass	2,638.9 lbs (1,197.0 kg)

Impact Conditions

Impact Velocity	63.11 mph (101.57 km/h)
Impact Angle	0.5°
Location / Orientation	Offset 16.9 in (430 mm) towards the passenger side
Kinetic Energy	328.2 kip-ft (444.9 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	66.3 ft (20.2 m) downstream 55.3 ft. (16.9 m) left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	3.7°
Maximum Pitch Angle	3.6°
Maximum Yaw Angle	107.8°

Occupant Risk

Longitudinal OIV	23.6 ft/s (7.2 m/s)
Lateral OIV	0.3 ft/s (0.1 m/s)
Longitudinal RA	-13.3 g
Lateral RA	3.5 g
THIV	23.6 ft/s (7.2 m/s)
PHD	13.3
ASI	0.68

Test Article Deflections

Static	N/A
Maximum Debris Field	33.7 ft. (10.3 m) left 110.8 ft. (33.8 m) forward

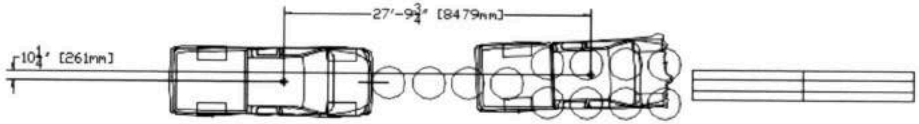
Vehicle Damage

Vehicle Damage Scale	12-FC-4
CDC	12FDEW3
Maximum Intrusion	Windshield

Figure 2 Summary of Test 3-40

MASH Test 3-41 Summary

0.000 s 0.200 s 0.400 s 0.600 s 1.100 s



General Information

Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P37007-01
Test Designation	3-41
Test Date	2/27/17

Test Article

Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	49.1 ft (15.0 m)
Road Surface	Cement

Test Vehicle

Type / Designation	2270P
Year, Make, and Model	2012 RAM 1500
Curb Mass	5,028.7 lbs (2,281.0 kg)
Test Inertial Mass	5,015.4 lbs (2,275.0 kg)
Gross Static Mass	5,015.4 lbs (2,275.0 kg)

Impact Conditions

Impact Velocity	62.96 mph (101.32 km/h)
Impact Angle	0.1°
Location / Orientation	0.5 in (13 mm) right of the article's centerline
Kinetic Energy	664.8 kip-ft (901.3 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	28.1 ft (8.6 m) downstream 10.3 in. (261 mm) left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	4.7°
Maximum Pitch Angle	6.7°
Maximum Yaw Angle	-4.5°

Occupant Risk

Longitudinal OIV	26.9 ft/s (8.2 m/s)
Lateral OIV	4.6 ft/s (1.4 m/s)
Longitudinal RA	-12.4 g
Lateral RA	2.2 g
THIV	27.2 ft/s (8.3 m/s)
PHD	12.5 g
ASI	0.82

Test Article Deflections

Static	N/A
Maximum Debris Field	65.5 ft. (20.0 m) left 101.9 ft. (31.0 m) forward

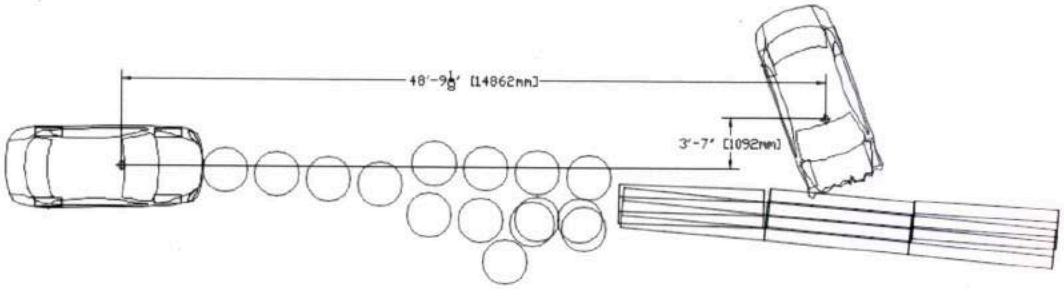
Vehicle Damage

Vehicle Damage Scale	12-FC-4
CDC	12FDEW3
Maximum Intrusion	Floorpan

Figure 2 Summary of Test 3-41

MASH Test 3-42 Summary

0.000 s 0.160 s 0.320 s 0.640 s 0.880 s



General Information

Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P37115-01
Test Designation	3-42
Test Date	4/14/17

Test Article

Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	59.1 ft (18.0 m)
Road Surface	Concrete

Test Vehicle

Type / Designation	1100C
Year, Make, and Model	2011 Kia Rio
Curb Mass	2,307.1 lbs (1,046.5 kg)
Test Inertial Mass	2,401.9 lbs (1,089.5 kg)
Gross Static Mass	2,572.8 lbs (1,167.0 kg)

Impact Conditions

Impact Velocity	66.58 mph (107.15 km/h)
Impact Angle	5.2°
Location / Orientation	1.0 in (25 mm) right of the vehicles centerline
Kinetic Energy	355.9 kip-ft (482.6 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	48.8 ft (14.9 m) downstream 3.6 ft. (1.1 m) left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	5.0°
Maximum Pitch Angle	-3.2°
Maximum Yaw Angle	28.8°

Occupant Risk

Longitudinal OIV	23.6 ft/s (7.2 m/s)
Lateral OIV	2.0 ft/s (0.6 m/s)
Longitudinal RA	-14.5 g
Lateral RA	2.8 g
THIV	23.6 ft/s (7.2 m/s)
PHD	14.5
ASI	0.8

Test Article Deflections

Static	N/A
Maximum Debris Field	54.6 ft. (16.6 m) left 105.3 ft. (32.1 m) forward

Vehicle Damage

Vehicle Damage Scale	12-FC-3
CDC	12FDEW2
Maximum Intrusion	Windshield

Figure 2 Summary of Test 3-42

MASH Test 3-43 Summary

0.000 s 0.050 s 0.100 s 0.200 s 0.350 s

General Information	
Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P37168-01
Test Designation	3-43
Test Date	05/18/17

Test Article	
Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	49.1 ft (15.0 m)
Road Surface	Concrete

Test Vehicle	
Type / Designation	2270P
Year, Make, and Model	2012 Ram 1500
Curb Mass	5,007.7 lbs (2,271.5 kg)
Test Inertial Mass	4,968.0 lbs (2,253.5 kg)
Gross Static Mass	4,968.0 lbs (2,253.5 kg)

Impact Conditions	
Impact Velocity	62.09 mph (99.92 km/h)
Impact Angle	5.6°
Location / Orientation	0.8 in (21 mm) left of the article's centerline
Kinetic Energy	640.3 kip-ft (868.1 kJ)

Exit Conditions	
Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	128.9 ft (39.3 m) downstream 10.1 ft. (3.1 m) left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	5.5°
Maximum Pitch Angle	3.7°
Maximum Yaw Angle	-7.8°

Occupant Risk	
Longitudinal OIV	23.6 ft/s (7.2 m/s)
Lateral OIV	1.3 ft/s (0.4 m/s)
Longitudinal RA	-9.1 g
Lateral RA	-2.3 g
THIV	23.6 ft/s (7.2 m/s)
PHD	9.4 g
ASI	0.59

Test Article Deflections	
Static	N/A
Maximum Debris Field	65.5 ft. (20.0 m) left 127.6 ft. (38.9 m) forward

Vehicle Damage	
Vehicle Damage Scale	12-FC-4
CDC	12FDEW3
Maximum Intrusion	Floorpan

Figure 2 Summary of Test 3-43

MASH Test 3-44 Summary

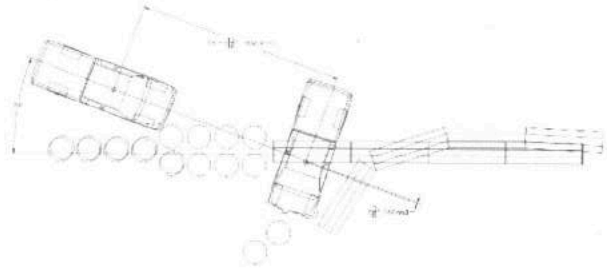
0.000 s

0.150 s

0.470 s

0.900 s

1.800 s



General Information

Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P36301-01
Test Designation	3-44
Test Date	03/02/17

Test Article

Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	49.1 ft (15.0 m)
Road Surface	Concrete

Test Vehicle

Type / Designation	2270P
Year, Make, and Model	2012 RAM 1500
Curb Mass	5,217.2 lbs (2,366.5 kg)
Test Inertial Mass	5,004.4 lbs (2,270.0 kg)
Gross Static Mass	5,004.4 lbs (2,270.0 kg)

Impact Conditions

Impact Velocity	60.32 mph (97.07 km/h)
Impact Angle	20.2°
Location / Orientation	0.6 in (15 mm) right of the intended impact point
Kinetic Energy	608.7 kip-ft (825.3 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	26.7 ft (8.1 m) downstream 2.4 in. (61 mm) left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-7.6°
Maximum Pitch Angle	1.9°
Maximum Yaw Angle	60.9°

Occupant Risk

Longitudinal OIV	31.2 ft/s (9.5 m/s)
Lateral OIV	3.6 ft/s (1.1 m/s)
Longitudinal RA	-24.4 g
Lateral RA	5.2 g
THIV	31.5 ft/s (9.6 m/s)
PHD	24.4 g
ASI	1.34

Test Article Deflections

Static	N/A
Maximum Debris Field	44.0 ft. (13.4 m) left 130.3 ft. (39.7 m) forward

Vehicle Damage

Vehicle Damage Scale	12-FC-5
CDC	12FDEW3
Maximum Intrusion	Floorpan

Figure 2 Summary of Test 3-44

MASH Test 3-44 Summary

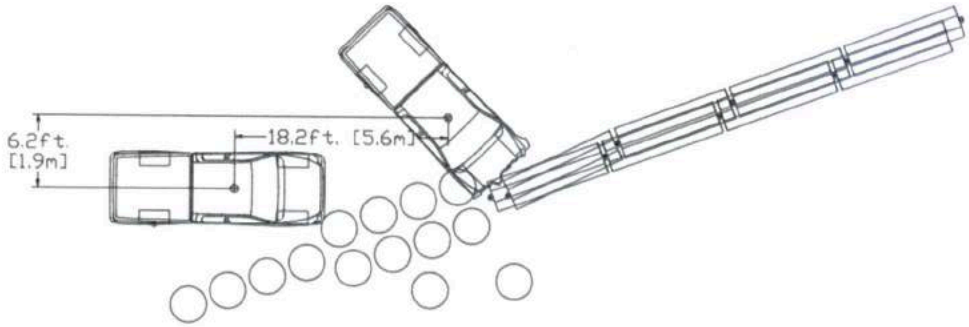
0.000 s

0.100 s

0.160 s

0.250 s

1.400 s



General Information

Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P38019-01
Test Designation	3-44
Test Date	01/05/18

Test Article

Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	49.1 ft (15.0 m)
Road Surface	Concrete

Test Vehicle

Type / Designation	2270P
Year, Make, and Model	2013 RAM 1500
Curb Mass	4,784.0 lbs (2,170.0kg)
Test Inertial Mass	4,995.6 lbs (2,266.0 kg)
Gross Static Mass	4,995.6 lbs (2,266.0 kg)

Impact Conditions

Impact Velocity	61.26 mph (98.59 km/h)
Impact Angle	19.9°
Location / Orientation	Center of vehicle to corner of backup structure
Kinetic Energy	626.7 kip-ft (849.7 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	18.2 ft (5.6 m) downstream 6.2 ft. (1.9 m) left
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	-6.1°
Maximum Pitch Angle	5.2°
Maximum Yaw Angle	-43.1°

Occupant Risk

Longitudinal OIV	35.8 ft/s (10.9 m/s)
Lateral OIV	4.3 ft/s (1.3 m/s)
Longitudinal RA	-23.3 g
Lateral RA	4.0 g
THIV	35.8 ft/s (10.9 m/s)
PHD	23.3 g
ASI	1.45

Test Article Deflections

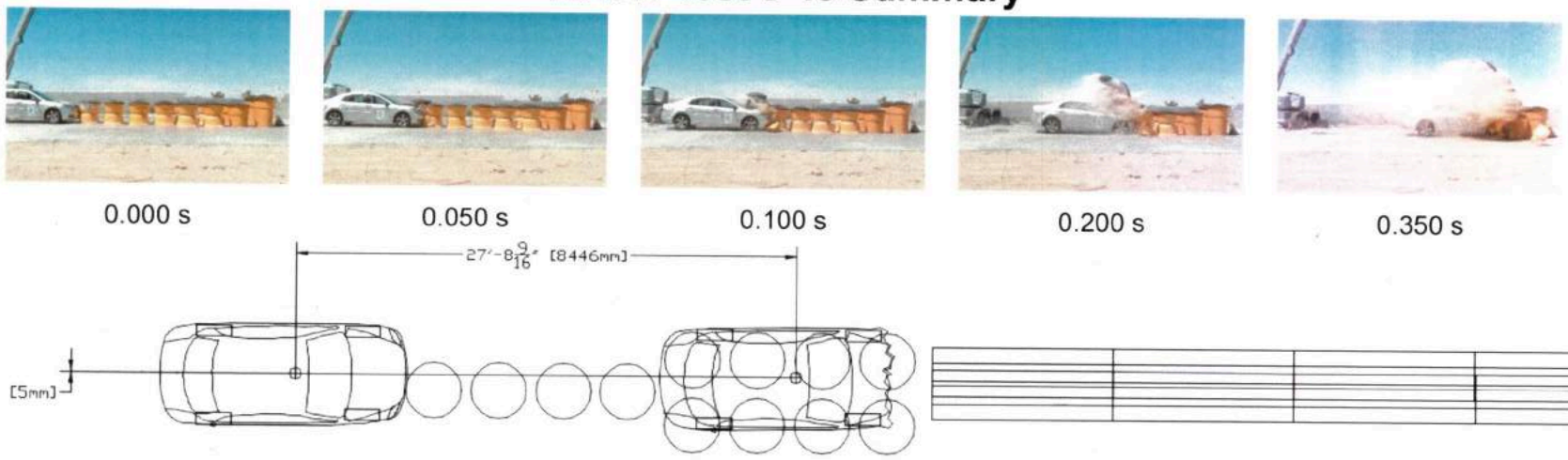
Static	N/A
Maximum Debris Field	30.9 ft. (9.4 m) left 83.7 ft. (25.5 m) forward

Vehicle Damage

Vehicle Damage Scale	12-FC-5
CDC	12FDEW3
Maximum Intrusion	Floorpan

Figure 2 Summary of Test 3-44

MASH Test 3-45 Summary



General Information

Test Agency	KARCO Engineering, LLC.
KARCO Test No.	P37167-01
Test Designation	3-45
Test Date	5/16/17

Test Article

Name / Model	Big Sandy
Type	Crash Cushion
Article Length	28.1 ft. (8.6 m)
Installation Length	49.1 ft (15.0 m)
Road Surface	Concrete

Test Vehicle

Type / Designation	1500A
Year, Make, and Model	2012 Chevrolet Malibu
Curb Mass	3,263.9 lbs (1,480.5 kg)
Test Inertial Mass	3,284.8 lbs (1,490.0 kg)
Gross Static Mass	3,284.8 lbs (1,490.0 kg)

Impact Conditions

Impact Velocity	61.31 mph (98.67 km/h)
Impact Angle	0.6°
Location / Orientation	0.6 in (16 mm) left of the article's centerline
Kinetic Energy	412.8 kip-ft (559.6 kJ)

Exit Conditions

Exit Velocity	N/A
Exit Angle	N/A
Final Vehicle Position	27.7 ft (8.4 m) downstream
Vehicle Snagging	None
Vehicle Pocketing	None
Vehicle Stability	Satisfactory
Maximum Roll Angle	5.6°
Maximum Pitch Angle	2.7°
Maximum Yaw Angle	-4.5°

Occupant Risk

Longitudinal OIV	22.3 ft/s (6.8 m/s)
Lateral OIV	0.7 ft/s (0.2 m/s)
Longitudinal RA	-13.8 g
Lateral RA	1.2 g
THIV	22.3 ft/s (6.8 m/s)
PHD	13.8 g
ASI	0.79

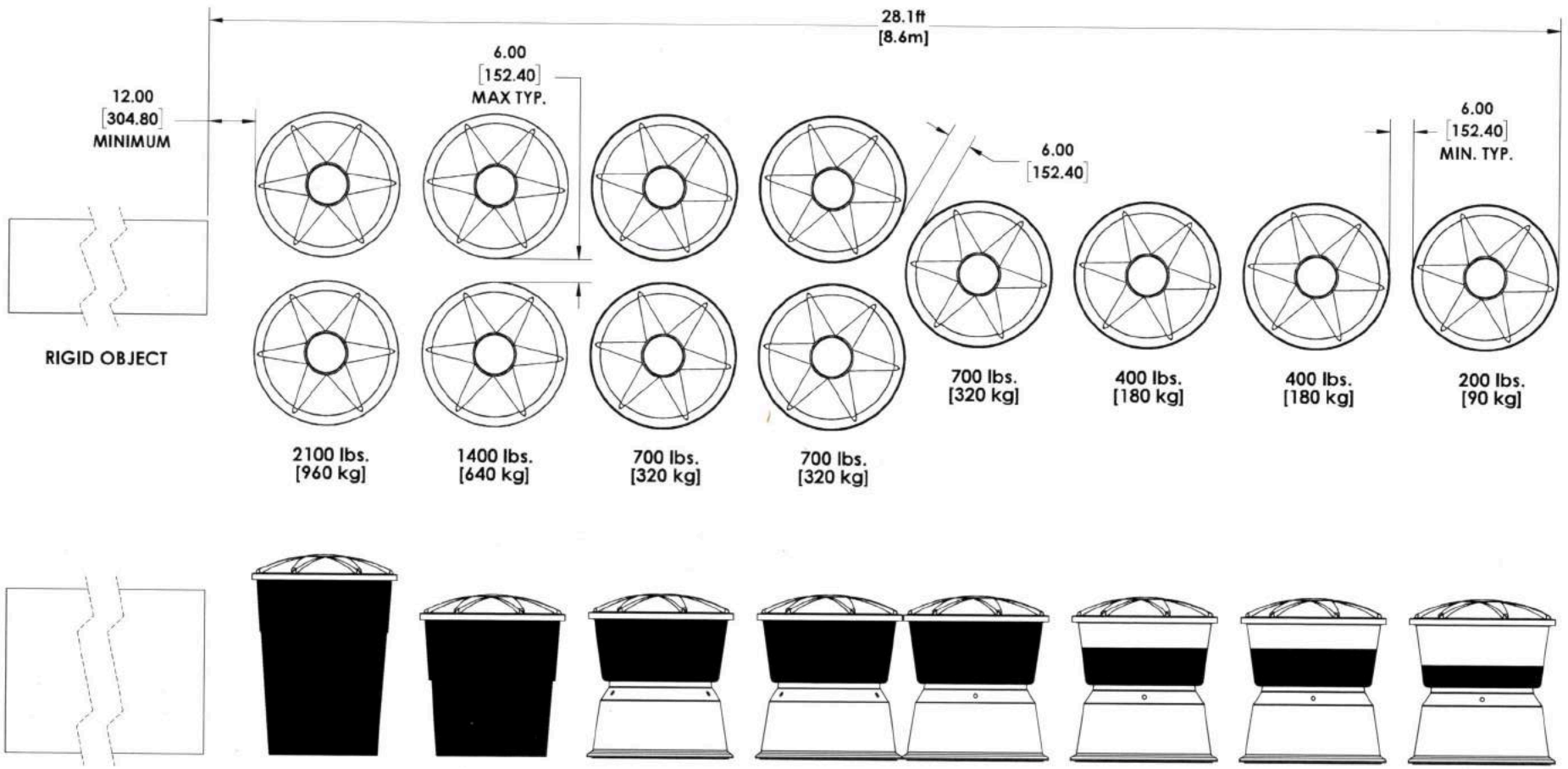
Test Article Deflections

Static	N/A
Maximum Debris Field	65.5 ft. (20.0 m) left 92.2 ft. (28.1 m) forward

Vehicle Damage

Vehicle Damage Scale	12-FC-4
CDC	12FDEW3
Maximum Intrusion	N/A

Figure 2 Summary of Test 3-45



UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES[mm].
TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
DEGREES: ± 0.5°

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TITLE:

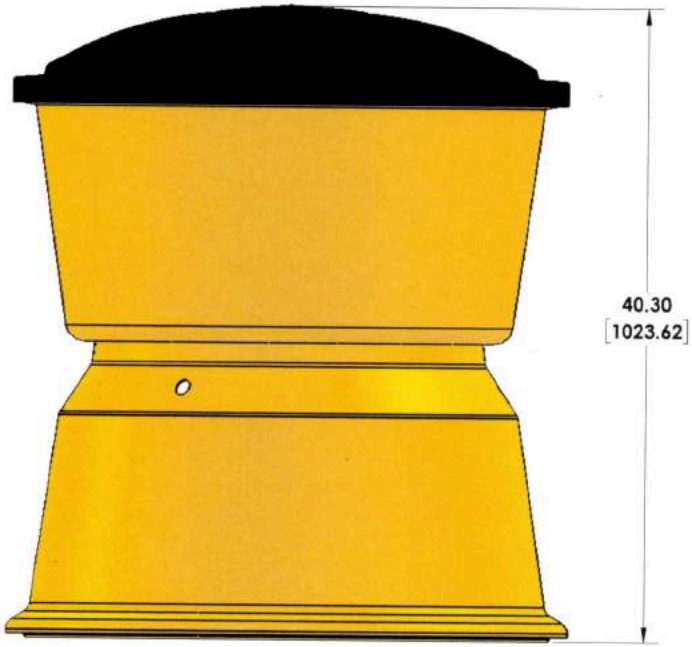
Big Sandy 12 Barrel Array

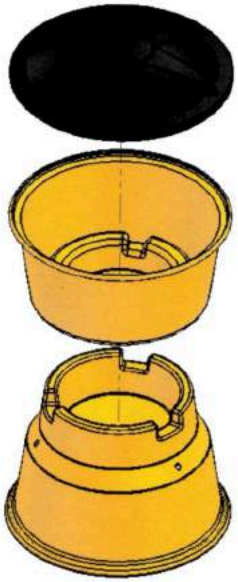
DRAWN BY:	DATE:
Christopher Jaime	2/22/17
CHECKED BY: FA	DATE: 2/22/17
APPROVED BY: FA	DATE: 2/22/17

SIZE B | DWG. NO. 200-100 | REV C

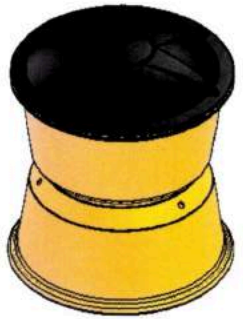
SHEET 1 OF 1

2. Weight: lbs. [kg]
1. Units: Inches [mm]
NOTES: UNLESS OTHERWISE SPECIFIED





Exploded View



Assembled View

1. Units: Inches [mm]
NOTES: UNLESS OTHERWISE SPECIFIED

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TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
X.XXX ± .015"
DEGREES: ± 0.5°

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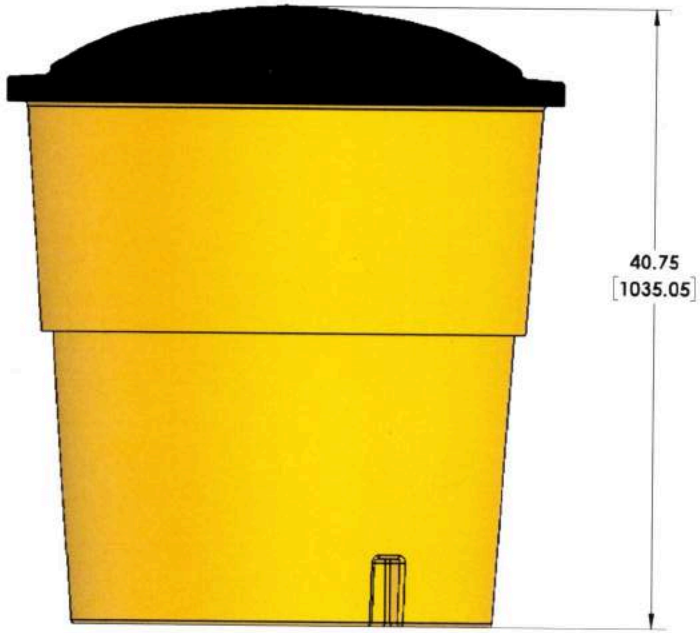
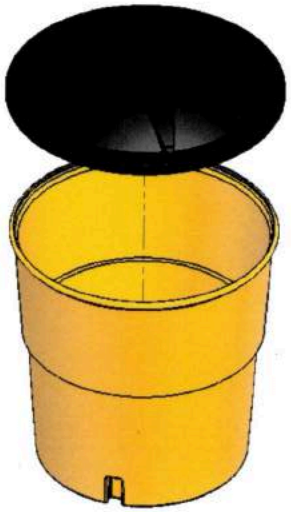
TITLE:

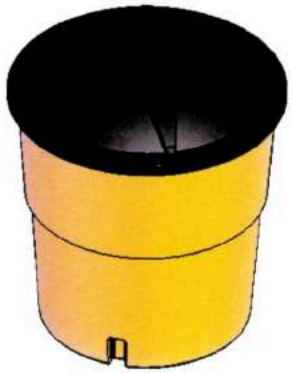
Big Sandy Combo Barrel

DRAWN BY: Christopher Jaime	DATE: 2/23/17	SIZE B	DWG. NO. 200-101	REV C
CHECKED BY: FA	DATE: 2/23/17			
APPROVED BY: FA	DATE: 2/23/17			SHEET 1 OF 1





Exploded View



Assembled View

1. Units: Inches [mm]

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES[mm].
TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
X.XXX ± .015"
DEGREES: ± 0.5°

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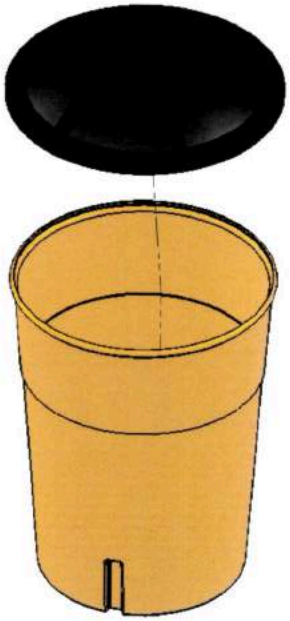
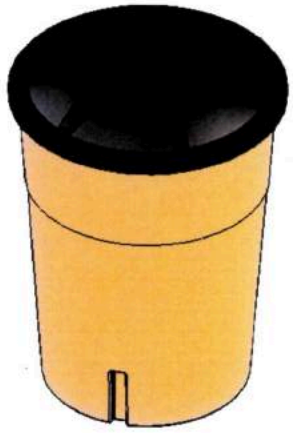
TITLE:

Big Sandy 1400 lbs. Barrel

DRAWN BY: Christopher Jaime	DATE: 2/23/17	SIZE B	DWG. NO. 200-102	REV C
CHECKED BY: FA	DATE: 2/23/17			
APPROVED BY: FA	DATE: 2/23/17			SHEET 1 OF 1



Exploded View



Assembled View

1. Units: Inches [mm]

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES[mm].
TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
X.XXX ± .015"
DEGREES: ± 0.5°

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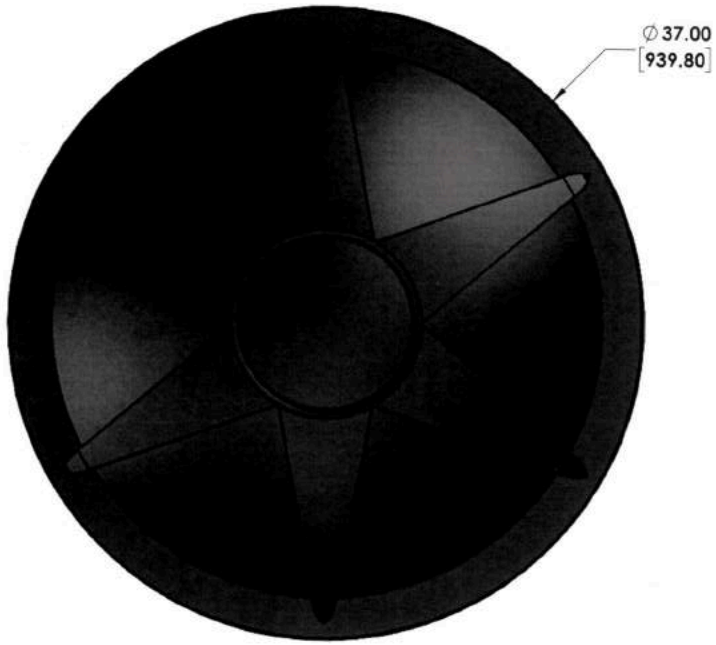
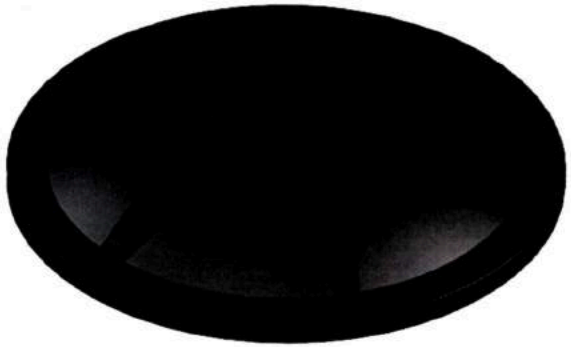
TITLE:

Big Sandy 2100 lbs. Barrel

DRAWN BY: Christopher Jaime	DATE: 2/23/17	SIZE B	DWG. NO. 200-103	REV C
CHECKED BY: FA	DATE: 2/23/17			
APPROVED BY: FA	DATE: 2/23/17			SHEET 1 OF 1





2. Material: Black Polyethylene Plastic
1. Units: Inches [mm]
NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES[mm].
TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
DEGREES: ± 0.5°

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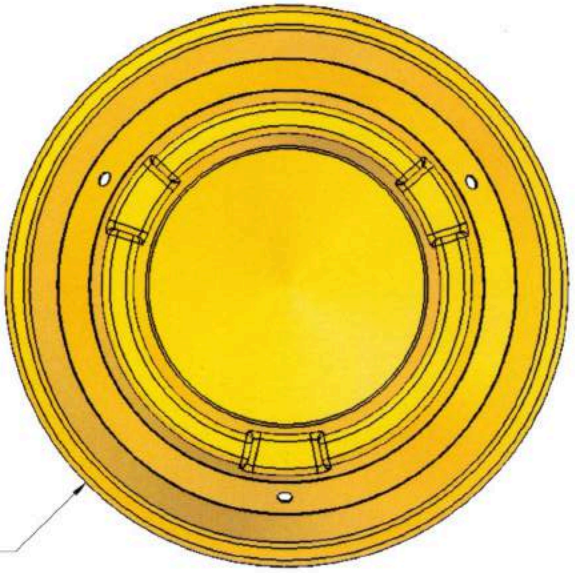
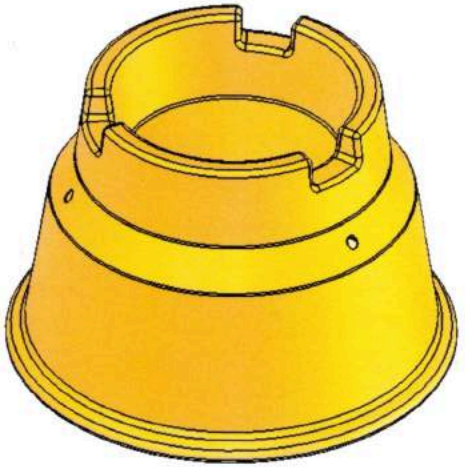
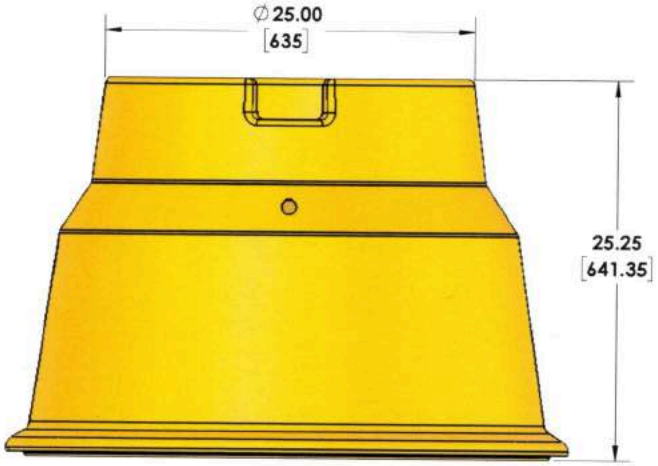
TITLE:

Big Sandy Lid

DRAWN BY: Christopher Jaime	DATE: 2/27/17	SIZE B	DWG. NO. 200-104	REV A1
CHECKED BY: FA	DATE: 2/27/17			
APPROVED BY: FA	DATE: 2/27/17			SHEET 1 OF 1







2. Material: Yellow Polyethylene Plastic
1. Units: Inches [mm]
NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES[mm].
TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
DEGREES: ± 0.5°

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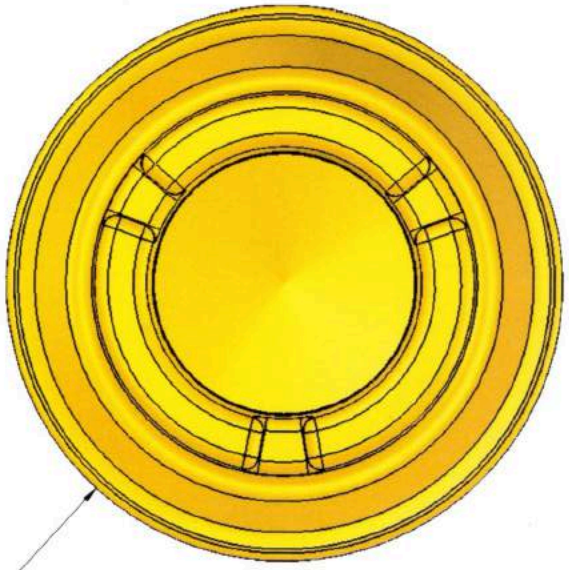
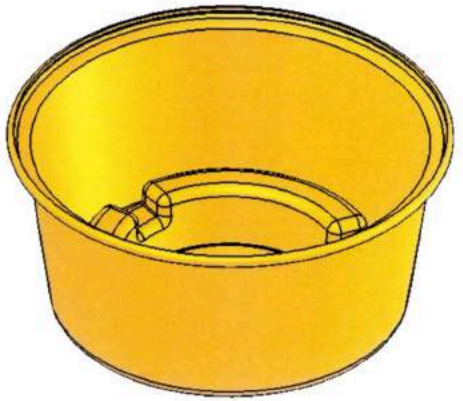
TITLE:

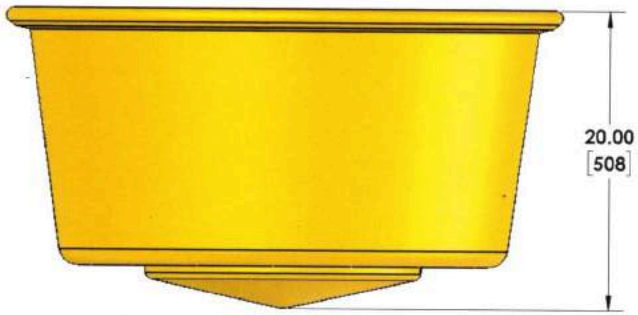
Pedestal, Big Sandy Combo Barrel

DRAWN BY: Christopher Jaime	DATE: 7/17/17	SIZE B	DWG. NO. 200-105	REV A
CHECKED BY: FA	DATE: 7/17/17			
APPROVED BY: FA	DATE: 7/17/17			

SHEET 1 OF 1







2. Material: Yellow Polyethylene Plastic
1. Units: Inches [mm]
NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED:
ALL DIMENSIONS ARE IN INCHES[mm].
TOLERANCES:
FRACTIONAL: X/X ± 1/16" [1.6mm]
DECIMAL: X.X ± .0625"
X.XX ± .032"
DEGREES: ± 0.5°

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TITLE:

Canister, Big Sandy Combo Barrel

DRAWN BY: Christopher Jaime	DATE: 7/17/17	SIZE B	DWG. NO. 200-106	REV A
CHECKED BY: FA	DATE: 7/17/17			
APPROVED BY: FA	DATE: 7/17/17			SHEET 1 OF 1