Implementation Guidance for the Tractor-Trailer GHG Regulation

1) List of Pre-Approved Modifications to SmartWay Verified Aerodynamic Equipment for Trailers, and

2) Requirements for Obtaining California Air Resources Board Approval for Modifications (Wind Tunnel Test Procedure)

Emission Research and
Regulatory Development Branch

October 2012

Version 1.0

I. Overview

A. What is the purpose of this document?

This document provides important information for manufacturers of aerodynamic technologies, trailer manufacturers, and trailer owners regarding modified U.S. EPA SmartWay verified aerodynamic technologies for trailers (SmartWay trailer technologies). Specifically, it provides a description of modifications that are currently pre-approved by the Executive Officer of the California Air Resources Board (CARB) as meeting the requirements of the Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Regulation (Tractor-Trailer GHG regulation/Regulation). This guidance also defines the wind tunnel-based method for obtaining Executive Officer approval for modifications to SmartWay trailer technologies that have not been pre-approved.

B. What does the Regulation require regarding the installation of modified SmartWay trailer technologies?

The Tractor-Trailer GHG regulation (sections 95300 to 95312, title 17, California Code of Regulations) requires owners of affected 53-foot or longer box-type trailers to install aerodynamic technologies on their trailers. These technologies must either be:

1. SmartWay trailer technologies, which by definition requires that they be installed in the same configuration as they were on the trailer used in the verification test, and installed on a trailer that is similar to the verification test trailer – a dry-van trailer in a standard dual-axle configuration, or

2. *Modified* SmartWay trailer technologies, provided the modification does not significantly increase the aerodynamic drag of the technology, and the owner has prior approval by the Executive Officer before installation.

The regulatory language pertinent to the installation of modified SmartWay trailer technologies is found in four separate sections of the Regulation:

- Section 95303(b)(1)(B)2.b. for 2011 and subsequent model year dry-van trailers,
- Section 95303(b)(2)(B)2.b. for 2011 and subsequent model year refrigerated-van trailers,
- Section 95303(b)(3)(B)2.b. for 2010 and previous model year dry-van trailers, and
- Section 95303(b)(3)(C)2.b., for 2010 and previous model year refrigerated-van trailers.

The regulatory language specifically related to this guidance reads as follows:

> *"Only modifications that are required to enable a particular SmartWay (verified) technology to be installed on a trailer are allowed. Such modifications must not significantly increase the aerodynamic drag of the base, unmodified SmartWay verified configuration, and the modifications may only be used if prior written approval is obtained from the Executive Officer. The Executive Officer will base his or her approval on information submitted that describes the modification, the need therefor, and any test data or other information that demonstrates the proposed modifications would not significantly increase the aerodynamic drag of the SmartWay verified configuration, and on good engineering judgment."*

C. What types of modifications do not require Executive Officer approval?

Modifications that do not invalidate a SmartWay trailer technology's verification status, as confirmed by the U.S. EPA, do not require Executive Officer approval. Recognizing that trailer structure differs between manufacturers, U.S. EPA staff has indicated that modifications that have "minimal" impact to the technologies' aerodynamic surfaces are allowed. These types of modifications include changes to trailer attachment points and hardware used to attach the technology to the trailer; and "minimal" changes to technology surfaces to allow for existing structures, e.g. landing gear.

If there is doubt as to whether a specific modification requires Executive Officer approval, contact CARB staff.

D. What are some examples of modifications to SmartWay trailer technologies that require Executive Officer approval?

In general, design changes to the shape, size, location, and rigidity of a SmartWay trailer technology in its operational configuration that are necessary for installation of the technology on a trailer, need Executive Officer approval. Examples of the types of modifications that require Executive Officer approval include the following:

- Removing portions of a side skirt to access a transport refrigeration unit (TRU) fuel tank cap and gauge on a refrigerated-van trailer
- Removing portions of a side skirt to allow for the opening and closing of belly box doors (A belly box is a storage box mounted to the underside of a trailer)
- Insetting a side skirt to accommodate intermodal use
- Mounting a side skirt in a location or orientation on the trailer that differs significantly from the verification location or orientation
- Cutting a side skirt closely behind the TRU fuel tank
- Shortening a side skirt on a spread-axle trailer to accommodate axle travel

E. Are there specific modifications that have been pre-approved by the Executive Officer?

Yes. Section II of this document, *Pre-approved Modifications*, provides a list of specific modifications that are pre-approved by the Executive Officer, requiring no further information or submittals on the part of the applicant. Thus, any modification to a SmartWay trailer technology that is identified in the list of specific modifications and meets the modification criteria defined in Section II is deemed approved by the Executive Officer and meets the requirements of sections 95303(b)(1)(B)2.b., 95303(b)(2)(B)2.b., 95303(b)(3)(B)2.b., and 95303(b)(3)(C)2.b. of the Regulation.

F. How do I obtain Executive Officer approval for modifications to SmartWay trailer technologies that are not pre-approved?

Section III of this document, *Requesting Approval of Modifications by the Executive Officer,* identifies the information that must be submitted to the Executive Officer when requesting approval of a modification to a SmartWay trailer technology. This section provides forms that can be used to request an approval. Test data showing that the proposed modifications would not significantly increase the aerodynamic drag of the SmartWay trailer technology must be included with the submittal. Section III also describes the CARB approved wind tunnel test procedure for evaluating modifications and the criteria that the Executive Officer will use to determine if the impact on aerodynamic drag is significant.

II. Pre-Approved Modifications

This section identifies and discusses the specific pre-approved modifications that require no additional information or submittals by the applicant. CARB staff may expand the list of pre-approved modifications in the future. All of the current pre-approved modifications pertain to SmartWay trailer technologies that are classified as either advanced trailer skirt or trailer side skirt technologies (referred to collectively as side skirt technologies). ARB enforcement personnel will evaluate modified SmartWay trailer technologies in the field and determine compliance based on the criteria presented in this document.

Pre-approving a modification to a side skirt technology was based on whether the modification was absolutely necessary for its proper installation. For example, side skirt technologies installed on refrigerated-van trailers, trailers with belly boxes, and spread-axle trailers need to be modified in order to allow refueling of TRU fuel tanks, viewing of TRU fuel tank gauges, moving the front trailer axles to their forward-most location, and the opening and closing of belly box doors. As another example, intermodal trailers subject to the retrofit requirements also

present unique installation challenges. Some verified side skirt technologies can interfere with the crane lift points installed on many in-use intermodal trailers. As a result, these side skirts would be subject to significant damage in normal railroad flatcar loading and off-loading operations if modifications were not made to them.

In addition to the "necessity" criteria discussed above, pre-approving a modification was also based on its impact on aerodynamic drag. To evaluate aerodynamic drag, staff reviewed the aerodynamic wind tunnel test data provided by three side skirt manufacturers. The wind tunnel tests were performed in accordance with the Society of Automotive Engineers (SAE) J1252 test procedure. The wind tunnel used for the tests was a scale model rolling road wind tunnel. The models used were built from scan data and data provided by the vehicle and equipment manufacturers. The resulting models were high fidelity 1/8 scale tractor-trailer models consisting of a U.S. EPA designated sleeper cab tractor model in combination with an industry standard 53-foot dry-van trailer. The tractor-trailer configurations tested included the baseline tractor-trailer configuration, tractor-trailers with TRU and TRU fuel tanks installed on the trailers, tractor-trailers with belly boxes installed under the trailers, tractor-trailers with several different SmartWay verified side skirts installed, and tractor-trailers with side skirts that had been modified as described in Table 1. Calculated wind averaged Coefficient of Drag (Cdw) values derived in accordance with SAE J1252 were determined for each configuration at several different vehicle operational speeds.

Based on engineering judgment, CARB staff determined that modifying a side skirt would result in a significant impact on aerodynamic drag if the Cdw increased by more than 10 percent of the difference between the Cdw of the baseline tractor-trailer (no SmartWay trailer technology) and the Cdw of the tractor-trailer with the SmartWay trailer technology installed in its unmodified verification configuration. The definition of significant impact can be expressed as follows:

A modification is considered to have a significant impact on aerodynamic drag reduction if the following expression holds true:

$$Cdw_{mod} > Cdw_{sw} + (Cdw_{base} - Cdw_{sw}) \times (0.10)$$

Where

Cdw_{mod} = the Cdw of a tractor-trailer with the modified SmartWay trailer technology installed (targeted dry-van or refrigerated-van trailer configuration with modified SmartWay trailer technology installed)

Cdw_{sw} = the Cdw of the tractor-trailer in its SmartWay verified configuration (dry-van trailer with unmodified SmartWay trailer technology installed)

Cdw_{base} = the Cdw of the baseline tractor-trailer (dry-van trailer with no aerodynamic technology installed)

Cdw values are calculated based on a range of yaw angles derived for a vehicle operational speed of 60 miles per hour (mph) and the continental United States average wind speed of 7 mph.

Table 1 summarizes the pre-approved modifications. Note that modifications 1 or 3 may be combined with modification 2 (see Table 1) on a single side skirt technology.

Table 1: Pre-approved modifications to SmartWay Side Skirt trailer technologies (as of September 2012)

Applies to side skirts installed on…		Modification description
1*	Refrigerated-van trailers	Maximum 6 inch diameter/ 8 inch length "U" cut to access TRU fuel tank cap (see Figure 1 for additional details.)
2*	Refrigerated-van trailers	Maximum 3 inch diameter hole to access TRU fuel tank gauge (see Figure 1 for additional details.)
3*	Refrigerated-van trailers	Maximum 8 inch diameter hole to access TRU fuel tank cap (see Figure 1 for additional details.)
4	Refrigerated-van trailers	Forward portion of side skirt cut to fit around TRU fuel tank with maximum 0.5 inch gap between TRU fuel tank and side skirt (see Figure 2 for additional details.)
5	Intermodal trailers	Inset side skirt up to 8 inches from lower edges of trailer sides with I-beams capped (see Figure 3 for additional details.)
6	Trailer with belly box	Side skirt cut to fit around belly box with maximum 0.5 inch gap between belly boxes and side skirt. (see Figure 4 for additional details.)
7	Spread-axle trailers with fixed axles.	Side skirt cut to fit area between landing gear and front trailer axle and area between front trailer axle and rear trailer axle. (see Figure 5 for additional details.)

* Modification 1 or 3 may be used in combination with modification 2.

Figure 1:Pre-approved modifications 1,2, and 3: Trailer side skirt with 6 inch diameter/8 inch length "U" cut to access TRU fuel tank cap, 3 inch diameter hole to acess TRU fuel tank gauge, and 8 inch diameter hole to access TRU fuel tank cap.

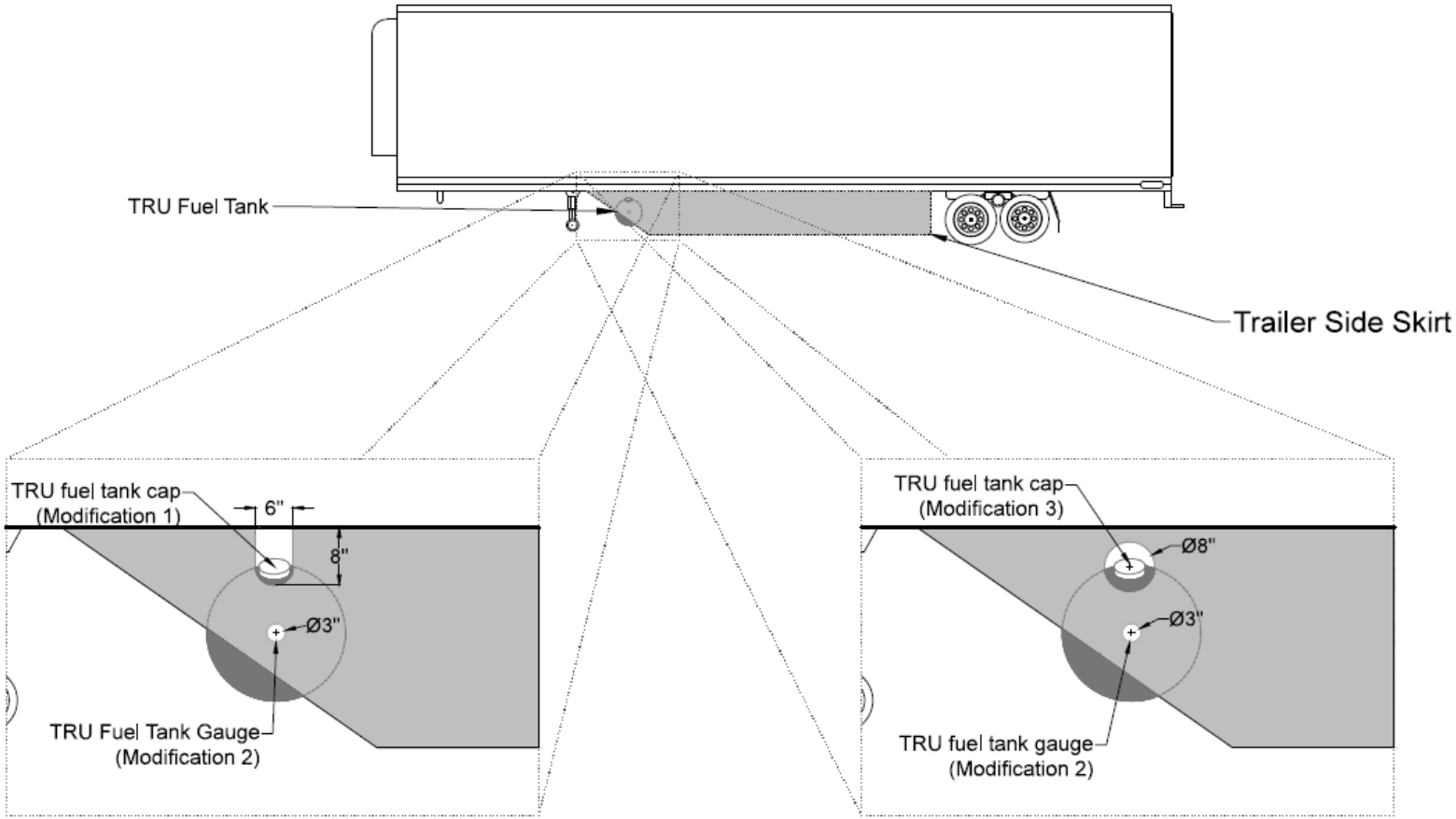


Figure 1a. 6"dia/8" long "U" cut (cap access)
3" dia hole (gauge access)

Figure 1b. 8" dia hole (cap access)
3" dia hole (gauge access)

Figure 2: Pre-approved Modification 4: Trailer side skirt cut along the contour of the TRU fuel tank (0.5 inch gap, maximum)

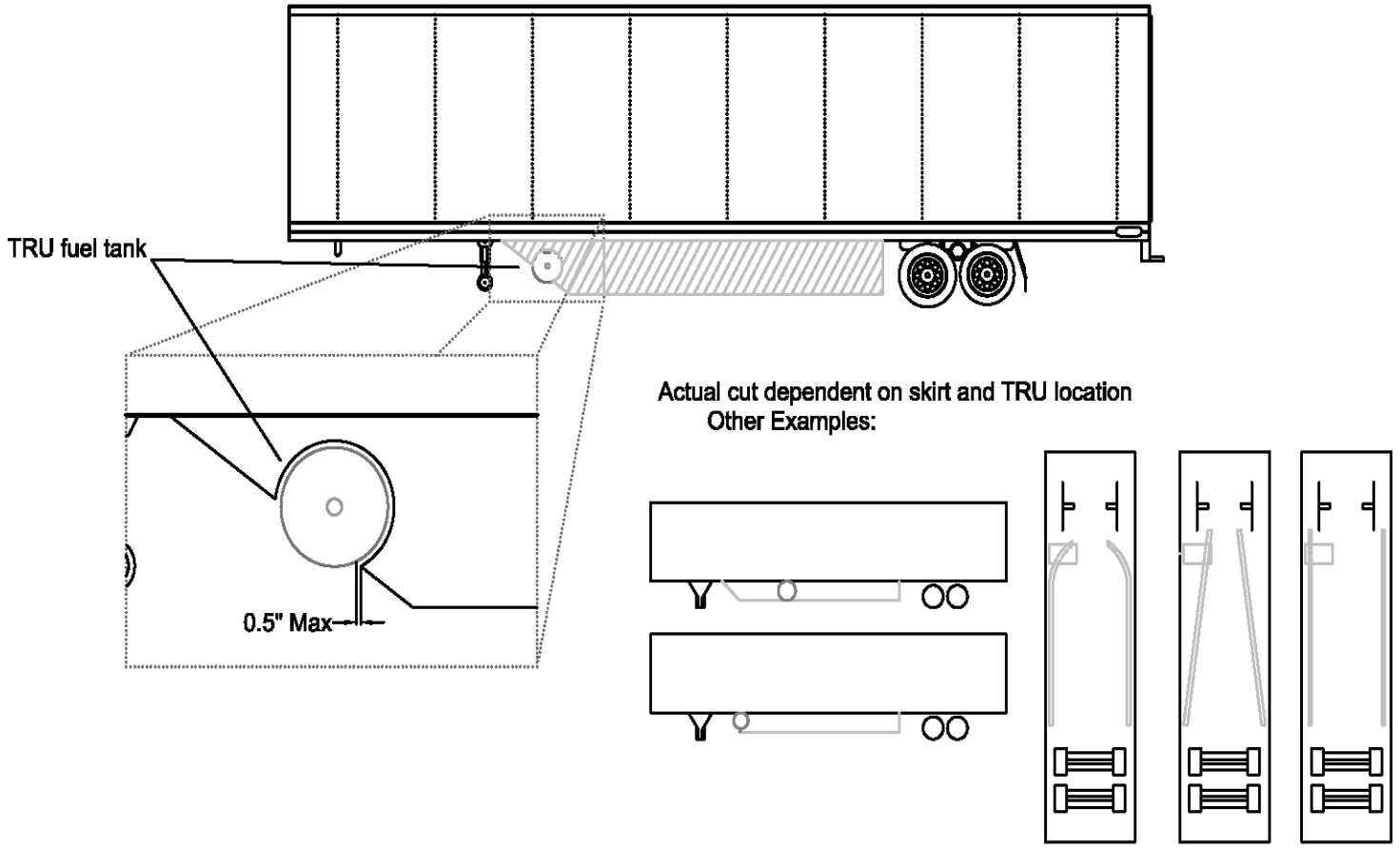


Figure 3: Pre-approved Modification 5: Trailer side skirt inset 8 inches from side; I-Beams capped

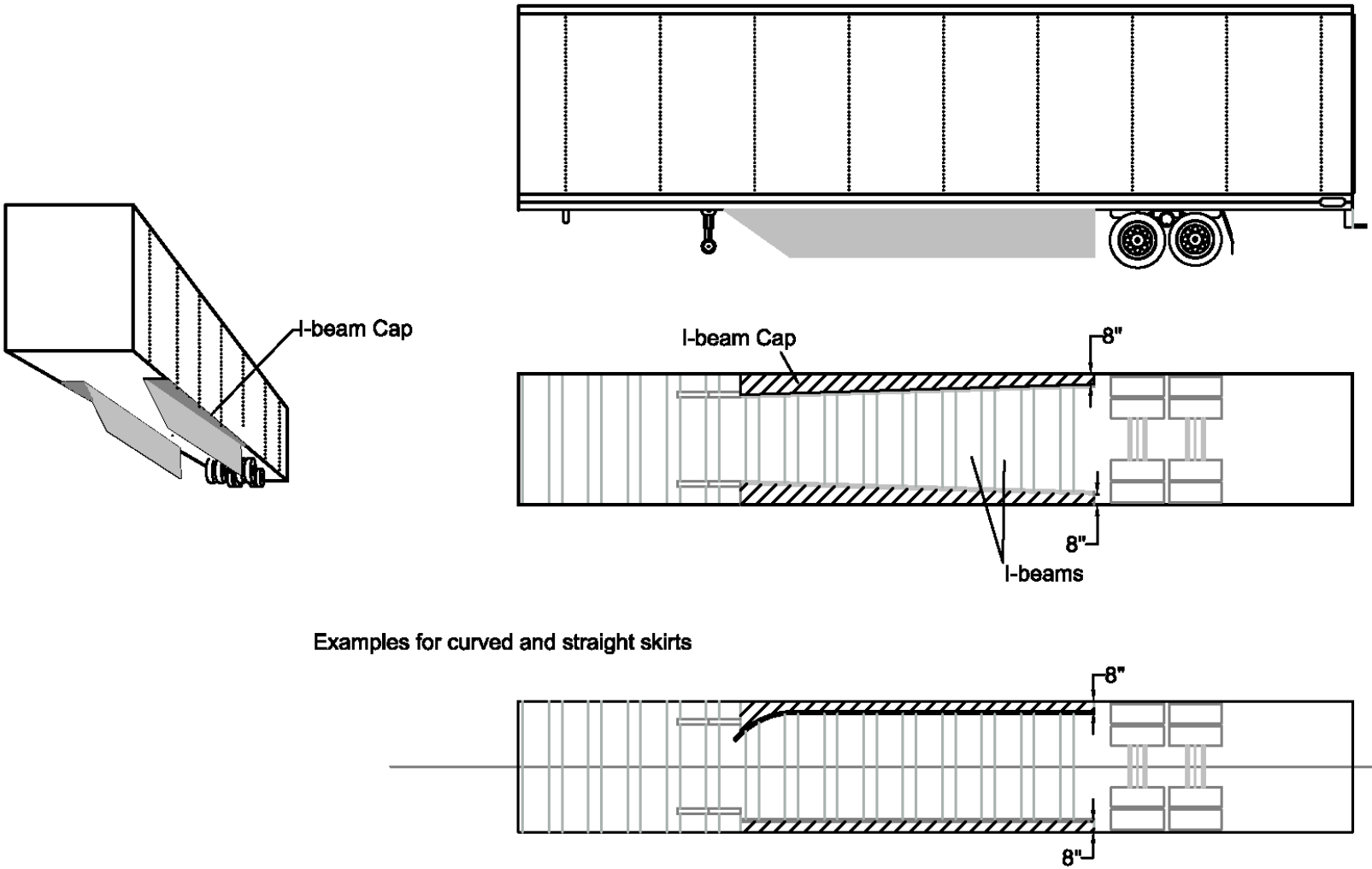


Figure 4: Pre-approved Modification 6: Trailer side skirt cut to fit around belly box with 0.5 inch gap, maximum

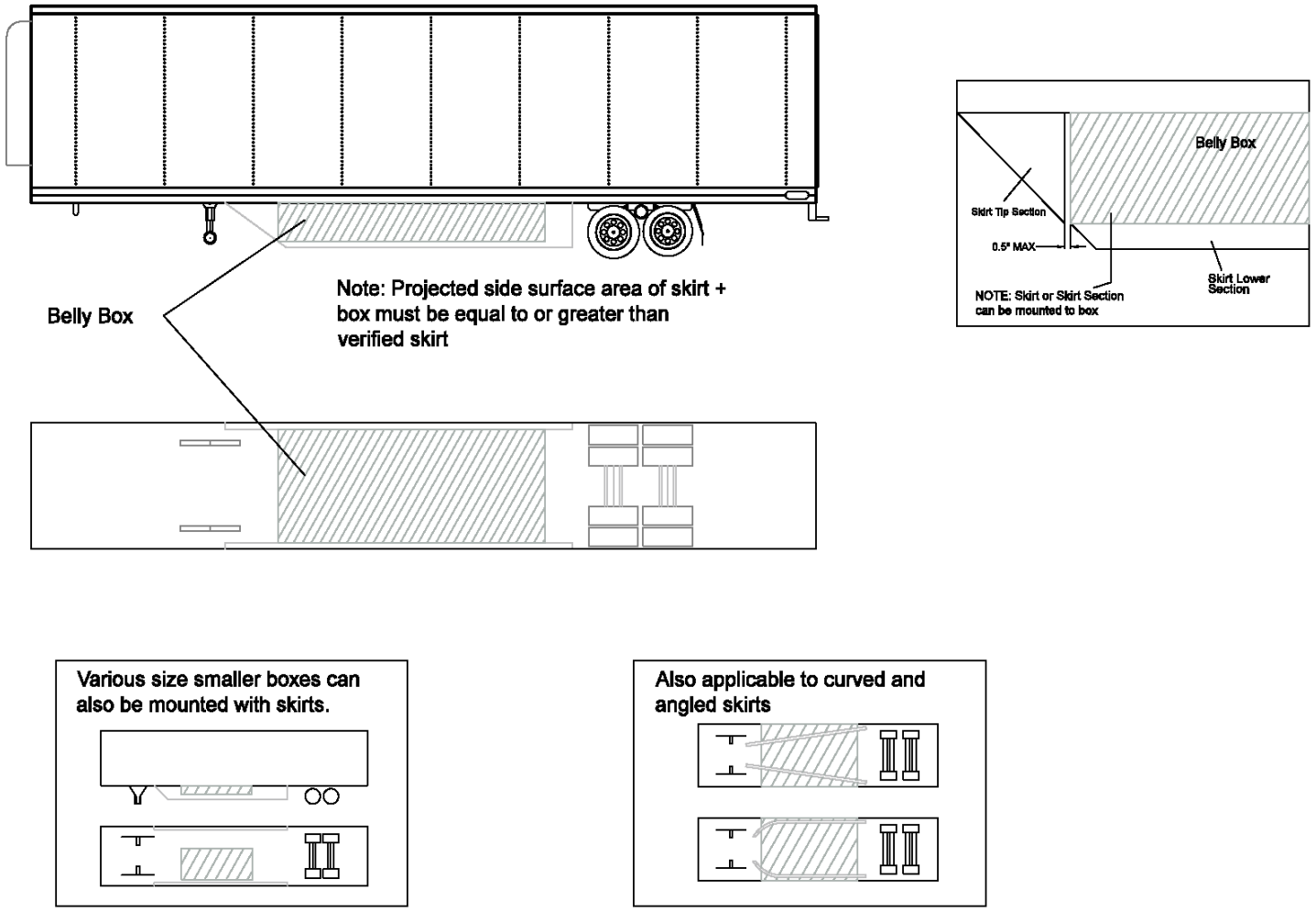
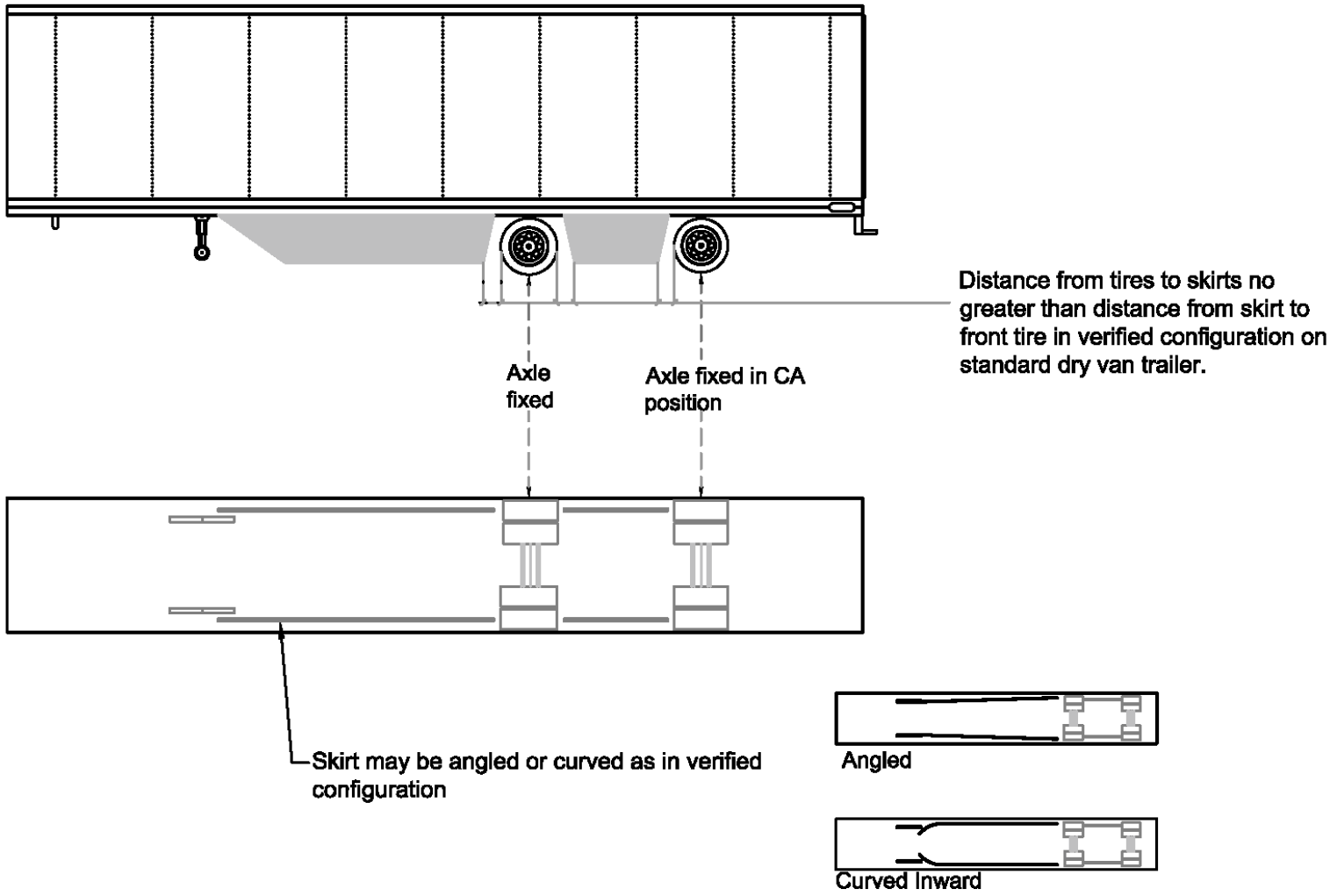


Figure 5: Pre-approved Modification 7: Spread-axle trailer side skirt cut to fit area between landing gear and front axle and area between front axle and rear axle



III. Requesting Approval of Modifications

Manufacturers of aerodynamic technologies, trailer manufacturers, and trailer owners may request approval from the Executive Officer for modifications to SmartWay trailer technologies that are not identified as pre-approved modifications. The approval process is a two-step process. For step 1, the applicant must provide the Executive Officer with a description of the modification and applicability of the modified SmartWay trailer technology. For step 2, the applicant must provide the Executive Officer with wind tunnel test results similar to those evaluated when defining the pre-approved modifications. The applicant should only proceed with Step 2 after the Executive Officer has reviewed the information submitted in Step 1, and has determined that the modification is necessary to allow for the proper installation of the technology on the subject trailer and no other compliance alternative exists. When evaluating the need for the modified device, the Executive Officer will also consider the availability of other SmartWay trailer technologies that can be installed without modification.

Following the Step 1 approval determination, the applicant should then proceed to Step 2 of the approval process and provide the Executive Officer with wind tunnel test results for the proposed modification. The wind tunnel test facility used to evaluate modifications must have prior experience in testing heavy duty trucks. It is also recommended that the facility be a Subsonic Aerodynamic Testing Association member in good standing. The test facility must also be capable of measuring an aerodynamic force increment that is less than or equal to 10 percent of the smallest reported difference in drag coefficient between the baseline tractor-trailer and the tractor-trailer equipped with the unmodified (or modified) SmartWay trailer technology. The Executive Officer may request data documenting the measurement sensitivity of the facility to ensure that data resolution is possible with an error band that is significantly less than the 10 percent increment in question.

Step 2 wind tunnel testing should be performed in accordance with the test procedure identified in Appendix 1, California Air Resources Board Wind Tunnel Test Procedure to Determine the Aerodynamic Drag Impact of a Modification to a U.S. EPA SmartWay Verified Trailer Aerodynamic Technology (CARB Wind Tunnel Test Procedure). The Executive Officer's approval decision will be based on comparisons of the Cdw values generated in the wind tunnel test for a baseline dry-van trailer, a baseline dry-van trailer equipped with the SmartWay trailer technology, and a trailer equipped with the modified SmartWay trailer technology. Each test will provide data over a yaw sweep necessary to achieve measurements required to calculate Cdw based upon the formula used for the calculation of wind averaged drag, which can be found in Appendix A of SAE J1252[1].

The mathematical expression as described in Section II [$Cdw_{mod} > Cdw_{sw}+(Cdw_{base}-Cdw_{sw})$ x (0.10)] will be used to evaluate the impact of the modifications on aerodynamic drag. If the inequality is true, the modification to the SmartWay Trailer technology is determined to have a significant impact on aerodynamic drag and, as such, is not approvable.

[1] SAE J1252, "Wind Tunnel Test Procedure for Trucks and Buses," July 16, 2012.

Appendix 2, Sample Submittal Template, provides a submittal template for both Step 1 and Step 2. They should be sent to:

Mail to: On Road Heavy Duty Diesel Section
Air Resources Board
9480 Telstar Avenue, Suite 4
El Monte, California 91731

E-mail to: 1TTGHG@arb.ca.gov

The Executive Officer will review the complete submittal and reserves the right to ask for any additional information, if deemed necessary, in order to approve or disapprove the submittal. If disapproved, the Executive Officer will provide the applicant with the reason for its disapproval.

APPENDIX 1

California Air Resources Board
Wind Tunnel Test Procedure to Determine the Impact of a Modification to a U.S. EPA SmartWay Verified Trailer Aerodynamic Technology on Coefficient of Drag

(October 2012)

1. Purpose:

(a) This document establishes a wind tunnel test procedure that an applicant can use to determine the impact of a modification to a U.S. EPA SmartWay verified trailer aerodynamic technology (SmartWay trailer technology) on the calculated wind averaged coefficient of drag (Cdw) of a vehicle configured with the modified technology when it is installed on a trailer.

1.1 Definitions

(a) *Baseline tractor-trailer* means a full-scale vehicle or a high fidelity detailed 1/8 scale or larger model of a tractor-trailer combination vehicle that is representative of a SmartWay designated tractor coupled to a standard 53-foot dry-van trailer. The tractor model must be designed to simulate airflow through the radiator inlet grill and across an engine geometry representative of those commonly used in the vehicle.

(b) *SmartWay tractor-trailer* means the baseline tractor-trailer with the SmartWay verified aerodynamic technology installed on the trailer in its verified configuration.

(c) *Modification* means:

(1) a physical change to a SmartWay trailer technology that results in the U.S. EPA no longer considering the changed device to be SmartWay verified, or

(2) the installation of a SmartWay trailer technology in a location or orientation on the trailer that differs from the SmartWay verification test configuration such that the U.S. EPA no longer considers the device to be SmartWay verified

(d) *Modified SmartWay tractor-trailer* means a full scale vehicle or a high fidelity detailed 1/8 scale or larger model of a tractor-trailer combination vehicle that is representative of a SmartWay designated tractor coupled to a 53-foot box-type trailer with the modified SmartWay verified aerodynamic technology installed.

(e) *Applicant* means the entity that wishes to determine the aerodynamic drag impact of a modification in accordance with this procedure. The applicant can be the manufacturer of the aerodynamic technology, the trailer manufacturer, the owner of the trailer, or any other interested party.

2. Wind Tunnel and Procedure Basics:

(a) The independent wind tunnel test facility (IWTTF) must

(1) be approved for use by the Executive Officer,

(2) have published test results that have been subject to a scientific or engineering peer review and accepted by industry, and

(3) satisfy the test facility requirements specified in SAE J1252[2], "SAE Wind Tunnel Test Procedure for Trucks and Buses" .

[2] SAE J1252, "SAE Wind Tunnel Test Procedure for Trucks and Buses," July 16, 2012.

3. Pre-test Requirements

(a) The applicant must provide CARB with a proposed schedule for testing and provide CARB with adequate notice should they wish to observe the testing.

(b) Test Tractor and Test Trailer Criteria

(1) CARB will determine which current SmartWay Certified tractor will be used or modeled for the wind tunnel test and reserves the right to approve or reject said model after being built, depending on whether the model conforms with CARB's specifications or not. If a scale model is being used, the data used to build the model must accurately represent the subject tractor. The model's scale, support method, and rigidity must satisfy the requirements of SAE J1252 criteria for the specific facility. Model fidelity must be sufficient to represent the critical aerodynamic features of the tractor for the test conditions and facility capability. The same tractor model will be used for the baseline tractor-trailer test, the SmartWay tractor-trailer test, and the modified SmartWay tractor-trailer test.

(2) The applicant will determine which trailer (or trailers) will be used or modeled for the wind tunnel test. If a scale model (or models) is being used, the data used to build the model (or models) must accurately represent the subject trailer (or trailers). The model's scale, support method, and rigidity must satisfy the requirements of SAE J1252 criteria for the specific facility and the aerodynamic technology being tested. Model fidelity must be sufficient to represent the critical aerodynamic features of the trailer for the test conditions and facility capability. The same trailer model will be used for the baseline tractor-trailer test and the SmartWay tractor-trailer test. SmartWay verified aerodynamic technologies and modified SmartWay verified aerodynamic technologies will be positioned on the trailer as per the instructions of the applicant.

(3) The trailer used or modeled for the modified SmartWay tractor-trailer test will differ from the baseline tractor-trailer test and the SmartWay tractor-trailer test only to the extent necessary to accurately represent the trailer. Accurately representing the real-world trailer configuration may require additional modifications including but not limited to the addition of a transport refrigeration unit (TRU), TRU fuel tank, belly box, third axle, or by reconfiguring the trailer axles in a spread-axle configuration.

(4) The modified SmartWay verified aerodynamic technology will be positioned on the modified SmartWay tractor-trailer as per the instructions of the applicant.

(5) The trailer used for the baseline tractor-trailer test and the SmartWay tractor-trailer test must meet the following specifications described in full scale dimensions:

(A) Bogey will be in the California bridge law position, kingpin to center of rear trailer axle=40 feet (California Vehicle Code section 35400(b)(4)).
(B) Full scale vehicle testing: kingpin 36 inches from front of trailer
(C) Tractor-to-trailer gap will be 45 +/- 2 inches for dry-van trailers and refrigerated-van trailers. The measurement is taken from the back of the cab to the front of the trailer.
(D) Trailer mud flaps will be placed in the factory standard position.

(E) Landing gear will be mounted in the trailer manufacturer's standard position.

(F) Front corner radius shall be according to trailer manufacturer's specifications (between 3" and 6").

(6) The applicant must provide CARB with the following information associated with the modified SmartWay trailer technology to be tested:

(A) Engineering drawings with critical dimensions of the trailer modeled for the SmartWay tractor-trailer test.

(B) Engineering drawings with critical dimensions of the trailer modeled for the modified SmartWay tractor-trailer test with the modified SmartWay verified aerodynamic technology installed.

4. Test Methodology:

(a) The IWTTF shall conduct aerodynamic tests at its wind tunnel facility to determine the Cdw of the baseline tractor-trailer, the SmartWay tractor-trailer, and the modified SmartWay tractor-trailer in accordance with SAE J1252, with the following exceptions and provisions.

(1) the minimum acceptable test Reynolds number shall be 1 million.
(2) The aerodynamic tests will include yaw angles of 0, 9, 6, 3, 1, 0, -1,-3, -6, -9, and 0 degrees. The coefficient of drag results from the first and last 0 degree yaw angle runs are used to check for repeatability and the remaining 9 collection points are used to calculate the Cdw for vehicle operational speeds of 50 miles per hour (mph), 55 mph, 60 mph, 65 mph, 70 mph, and 75 mph .
(3) The IWTTF shall run three repeats of the baseline tractor-trailer test, taking into account the measurement sensitivity of the wind tunnel.

5. Final Report Requirements

(a) The applicant shall generate a detailed report of the test and provide the specific information listed below.

(1) IWTTF name, street address, city, state, zip code

(2) The facility test aerodynamicist on site for the test

A. Dated signature of aerodynamicist on site.

(3) The date of the test.

(4) Scale model set-up and installation information should be provided for each tractor-trailer tested.

(5) Description of Tractor-Trailers

A. Tractor specifications, including

1. Manufacturer, year, model, wheelbase and tire size
2. Number of axles, suspension type
3. Sleeper type, size and roof fairing type.
4. Fuel tank sizes and position.
5. Engine year, make, model, size and family (for full-scale tractor-trailers only).
6. Tractor-to-trailer gap, mud flap style and location
7. Photographs of tractor-trailers used

B. For both the SmartWay tractor-trailer and the modified SmartWay tractor-trailer, full-scale trailer specifications, including

1. Trailer manufacturer
2. Trailer type (e.g., dry van, refrigerated van)
3. Trailer axle configuration
4. Trailer model year
5. Trailer model name
6. Trailer length, height, width
7. Bogey position from rear of trailer to center of rear trailer axle (inches)
8. Kingpin position (for full-scale tractor-trailers only), front corner radius
9. Tire size, mud flap location and type
10. If applicable, TRU make, model
11. If applicable, TRU fuel tank size and location
12. SmartWay verified aerodynamic technology manufacturer and model name
13. Photographs of tractor-trailers used

(6) Description of IWTTF

A. General Facility Information

1. Background/history
2. Layout
3. Wind tunnel type
4. Diagram of wind tunnel layout
5. Structural and material construction

B. Wind Tunnel Design Details

1. Corner turning vane type and material
2. Air settling method
3. Mesh screen specification
4. Air straightening method
5. Tunnel volume
6. Surface area
7. Average duct area
8. Circuit length

C. Wind Tunnel Flow Quality

1. Temperature control and uniformity
2. Airflow quality
3. Minimum airflow velocity
4. Flow uniformity
5. Angularity / stability
6. Static pressure variation
7. Turbulence intensity (percent turbulence)
8. Test duration flow quality

D. Test/Working Section Information

1. Test section type (e.g., open, closed, adaptive wall) and shape (e.g., circular, square, oval)
2. Length
3. Contraction ratio
4. Maximum air velocity
5. Maximum dynamic pressure
6. Nozzle width and height
7. Plenum dimensions and net volume
8. Maximum allowed model scale
9. Maximum model height above road
10. Strut movement rate (if applicable)
11. Model support
12. Primary boundary layer slot
13. Boundary layer elimination method
14. Photos and diagrams of the test section

E. Fan Section Description

1. Fan type
2. Fan diameter
3. Fan power
4. Fan maximum rotational speed
5. Fan maximum tip speed
6. Fan support type
7. Fan mechanical drive
8. Fan sectional total weight

F. Data Acquisition and Control (where applicable)

1. Acquisition type
2. Motor control
3. Tunnel control
4. Model balance
5. Model pressure measurement
6. Wheel drag balances
7. Wing/body panel balances
8. Model exhaust simulation

G. Moving Ground Plane or Rolling Road (if applicable)

1. Construction and material
2. Yaw table size and range
3. Moving ground length and width
4. Belt type
5. Maximum belt speed
6. Belt suction mechanism
7. Platen instrumentation
8. Temperature control
9. Steering

H. Facility Correction Factors and Purpose

(7) Test Results: The test run results should be presented in the report in PDF and hard copy format similar to the format presented in Appendix A.

Appendix A

Wind Tunnel Test Run Data
Example Format

Table 1: Baseline Tractor-Trailer Model

Photo of Baseline Tractor –Trailer	Test Run #	Description	Coefficient of Drag (Cd) vs. Yaw Angle of Attack (AoA)		Wind-Averaged Cd of Baseline Tractor –Trailer Model (Cdw_{base}) calculated for several operational vehicle speeds	
			Yaw Angle	Cd	Operational Vehicle Speed (mph)	Cdw(base)
(Side-view photograph of baseline tractor-trailer)	1	*(Example: Tractor: 2009 XYZ Model* *Trailer: 2009 ABC 53' dry van)*	0.000	0.XXX	50	0.XXX
			1.000	0.XXX	55	0.XXX
			3.000	0.XXX	60	0.XXX
			6.000	0.XXX	65	0.XXX
			9.000	0.XXX	70	0.XXX
			0.000	0.XXX	75	0.XXX
			-1.000	0.XXX		
			-3.000	0.XXX		
			-6.000	0.XXX		
			-9.000	0.XXX		
			0.000	0.XXX		

Table 2: SmartWay Tractor-Trailer Model

Photo of SmartWay Tractor-Trailer	Test Run #	Description	Coefficient of Drag (Cd) vs. Yaw Angle of Attack (AoA)		Wind-Averaged Cd of Baseline Tractor –Trailer Model (Cdw_{sw}) calculated for several operational vehicle speeds	
			Yaw Angle (degrees)	Cd	Operational Vehicle Speed (mph)	Cdw_{sw}
(Side-view photograph of SmartWay tractor-trailer)	1	*(Example: Tractor:2009 XYZ Model* *Trailer: 2009 ABC 53' dry van with EFG Side Skirt, model XXXXXXX)*	0.000	0.XXX	50	0.XXX
			1.000	0.XXX	55	0.XXX
			3.000	0.XXX	60	0.XXX
			6.000	0.XXX	65	0.XXX
			9.000	0.XXX	70	0.XXX
			0.000	0.XXX	75	0.XXX
			-1.000	0.XXX		
			-3.000	0.XXX		
			-6.000	0.XXX		
			-9.000	0.XXX		
			0.000	0.XXX		

Table 3: Modified SmartWay Tractor-Trailer Model

Photo of Modified SmartWay Tractor-Trailer	Test Run #	Description	Coefficient of Drag (CD) vs. Yaw Angle of Attack (AoA)		Wind-Averaged CD of Baseline Tractor–Trailer Model (Cdw_{mod}) calculated for several operational vehicle speeds	
			Yaw Angle (degrees)	Cd	Operational Vehicle Speed (mph)	Cdw_{mod}
(Side-view photograph of Modified SmartWay tractor-trailer)	1	*(Example: Tractor: 2009 XYZ Model* *Trailer: 2009 ABC 53' refrigerated van, tri-axle, EFG Side Skirt, model XXXXXXX, both skirts trimmed to 100 inches in length to accommodate tri-axle, Left skirt cut to allow TRU fuel access.)*	0.000	0.XXX	50	0.XXX
			1.000	0.XXX	55	0.XXX
			3.000	0.XXX	60	0.XXX
			6.000	0.XXX	65	0.XXX
			9.000	0.XXX	70	0.XXX
			0.000	0.XXX	75	0.XXX
			-1.000	0.XXX		
			-3.000	0.XXX		
			-6.000	0.XXX		
			-9.000	0.XXX		
			0.000	0.XXX		

APPENDIX 2

Sample Submittal Templates for Step 1 and Step 2

Request for Approval of a Modified SmartWay Verified Aerodynamic Technology for Use in Meeting the Requirements of the Tractor-Trailer GHG Regulation

Step 1: Submittal of Applicant Information and Description of Modification and Applicability for: (Insert name of technology and brief description of proposed modification.)

Submitted by:
Date of submittal:

A. Applicant Information

1. Company Name/Individual Name:		
2. Is Company/Individual SmartWay Verified Technology end user, distributor, or manufacturer?		
3. Contact Name and Title:		
4. Business Mailing Address and Contact Information: Street:		
City:	State:	Zip Code:
Phone: ( )	Fax: ( )	
Email:		

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

B. Description of Modification and Applicability

1. Provide a narrative description of the proposed modification to the SmartWay Verified Technology and the reason why the modification is necessary. (If more space is needed include additional pages as Attachment 1 to this submittal.)

B. Description of Modification and Applicability (cont.)

2. Provide engineering drawings of the modified technology installed on a trailer with all pertinent dimensions. If possible, include photographs of modified device installed on trailer.
(Include as Attachment 2 to this submittal.)
3. Identify the trailer group that the applicant is seeking approval for with this submittal. The trailer group could be trailers configured exactly as defined in Attachment 2, or trailers that are configured differently. Include engineering drawings that illustrate the range of pertinent dimensions of the trailer group. (If engineering drawings are to be submitted, include as Attachment 3 to this submittal.)

Request for Approval of a Modified SmartWay Verified Aerodynamic Technology for Use in Meeting the Requirements of the Tractor-Trailer GHG Regulation

Step 2: Submittal of Wind Tunnel Test Results for: (Insert name of technology and brief description of proposed modification from Step 1.)

Submitted by:
Date of submittal:

A. Applicant Information

1. Company Name/Individual Name:		
2. Is Company/Individual SmartWay Verified Technology end user, distributor, or manufacturer?		
3. Contact Name and Title:		
4. Business Mailing Address and Contact Information: Street:		
City:	State:	Zip Code:
Phone: ( )	Fax: ( )	
Email:		

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

B. Evaluating Significance of Modification Using Wind Tunnel Test Results

1. Provide copy of final report generated in accordance with section 5(a), California Air Resources Board Wind Tunnel Procedure to Determine the Aerodynamic Drag Impact of a Modification to a U.S. EPA SmartWay Verified Trailer Aerodynamic Technology, September 2012. (ARB Wind Tunnel Test Procedure)
(Include as Attachment 4 to this submittal.)
2. Using the results from the wind tunnel test fill in the values in Table 1 and perform the required calculations.

Table 1: Evaluating Significance of Modification

	Wind-averaged coefficient of drag (Cdw) values		F values $F=[Cdw_{base}-Cdw_{sw}]x\ 0.10$	Significant Impact Evaluation If Cdw_{mod} is less than or equal to $[Cdw_{sw}+F]$, then impact is not significant	
Speed (MPH)	**Cdw_{base}**	**Cdw_{sw}**	**F**	**Cdw_{mod}**	**Cdw_{sw} +F**
60					

Cdw_{base}= Wind-averaged coefficient of drag of baseline tractor-trailer model
Cdw_{sw}= Wind-averaged coefficient of drag of SmartWay tractor-trailer model.
Cdw_{mod}= Wind-averaged coefficient of drag of modified SmartWay tractor-trailer model.