ASSESSING BUMPER TECHNOLOGY FOR A NO-COMPROMISE SOLUTION

Fleets need end-to-end fuel efficient solutions — this whitepaper looks at bumper technologies and how advanced design and materials can mean a fuel efficient while also durable and easier to maintain bumper solution.

HENDRICKSON
Truck Commercial Vehicle Systems

With today's economic climate and environmental responsibilities, fuel efficiency is a major concern for trucking fleets. Balancing these, as well as regulations concerning greenhouse gas (GHG) emissions with the desire to improve overall operating costs leads many to focus on weight reductions and aerodynamics.

Among those strategies, a common solution may be to shift from traditional metal bumpers to lightweight plastic bumpers that appear to be more aerodynamic. But at what cost? Simple plastic bumpers can be less visually appealing and more vulnerable to suffering frequent damage in moderate operating conditions, which can cost money and undermine any savings attained through weight reduction.

The market needs an option that provides durability without compromising fuel efficiency or adding additional weight. Hendrickson Bumper and Trim, a division of Hendrickson USA, L.L.C., led an extensive study of aerodynamics that resulted in the development on an innovative bumper material that addresses this need.

This whitepaper first examines the basics of aerodynamics, the common misconceptions regarding fuel efficiency and the methods of testing available. It then introduces a specific bumper technology, outlining in a detailed methodology and summary of results specifically how the research study validated the performance of what is now known as AERO CLAD® material.

Basics of Aerodynamics

Aerodynamics is the study of the force of air and the resulting motion of objects through the air. Properties examined in aerodynamics include velocity, pressure, density, temperature, position and time.

Air resistance, or drag, has a large impact on how an object moves through the air. As an object moves, it displaces air. The more aerodynamic the object, the more easily it will displace the air surrounding it. The drag coefficient is the mathematical variable used to calculate the force of air resistance that the object is subjected to. You can see at right the technical equation used to determine drag force.

Equating Drag Force

Drag force is determined by the following equation:

$$F_d = c_d A p \frac{V^2}{2}$$

- **Fd** is the drag force on the object
- **cd** is the drag coefficient related to the object's geometry and taking into account skin friction and form drag
- **A** is the reference area (frontal area)
- **p** is the mass density of the fluid (air)
- **V** is the velocity of the object relative to the fluid

Volvo bumper used in fuel consumption test procedure.

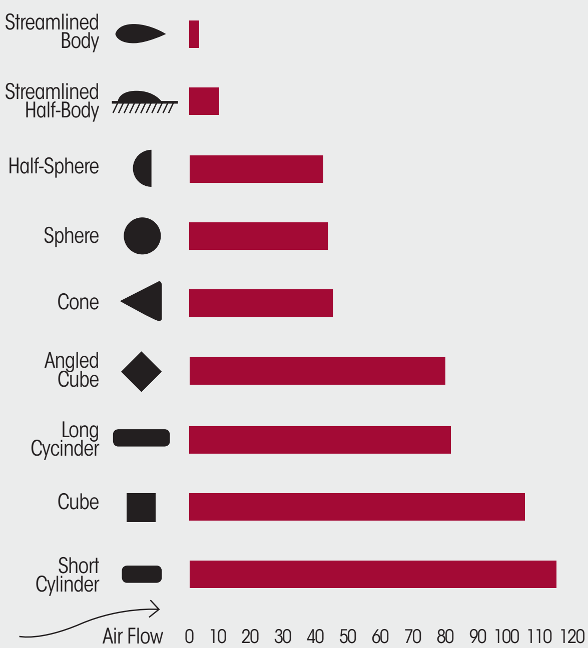
Cascadia bumper used in fuel consumption test procedure.

ProStar bumper used in fuel consumption test procedure.

In relation to the trucking industry, air displacement affects the way a vehicle accelerates, how it handles on the road and how it consumes fuel. A manufacturer's greatest opportunity to manipulate the drag coefficient is through surface area, i.e. size and shape. The graph (at right) best illustrates shape and the resulting drag coefficients.

An object with a box-like shape and larger surface area will show a greater drag coefficient, making it less aerodynamic. Conversely, a teardrop shape, with its round shape in front and smaller overall surface area, allows for a more streamlined airflow, thus exhibiting a lower drag coefficient and dispersing air more efficiently [a].

Measured Drag Coefficients



Air is introduced from the left and flows left to right over the objects to create drag.

MISCONCEPTIONS REGARDING FUEL EFFICIENCY

Anyone who drives a car is familiar with the term fuel economy. However, many do not realize that fuel economy and fuel efficiency are not interchangeable terms. Understanding the difference is imperative to discovering how to impact fuel-related savings.

Fuel economy, which is more commonly used by consumers, is measured in miles per gallon. Fuel efficiency, on the other hand, is a more descriptive term that measures how effective a vehicle is at using the fuel it has consumed within a set duration of travel. Interpreting improvements in fuel economy can be misleading in that the analysis doesn't directly acknowledge the total amount of fuel being used or the distance of a given journey. This can skew the results to make journeys of greater distances appear to exhibit greater improvements in gas mileage, and vice versa. Whereas, with fuel efficiency, the focus is clear. You need only compare how many gallons were required to travel in a given distance. This makes tracking changes simpler and more beneficial[b].

Fuel consumption is a third term that sometimes gets misinterpreted. Fuel consumption is synonymous with fuel efficiency, again looking at the number of gallons it takes to travel a set distance. Fuel consumption also can refer to a type of testing used to measure fuel efficiency.

A Change in Design for Improved Aerodynamics and Durability

Though many in the trucking industry believe conventional plastic bumpers to be the most economical option, Hendrickson Bumper and Trim pioneered the use of a robust lightweight metal bumper with a chrome-like appearance now called AERO CLAD.. A combination of aluminum and stainless steel, AERO CLAD material is 10 times thicker than chrome plating and exhibits a corrosion-resistant finish — even after damage from impact — and is designed to resist chipping, cracking and peeling.

METHODS OF ANALYSIS AND TESTING

Vehicle and equipment manufacturers use a variety of methods to measure the aerodynamics and fuel efficiency of their designs.

Computational fluid dynamic (CFD) utilizes software with numerical methods and algorithms to determine the flow around an object. CFD is commonly used to predict the effect of multiple design variations. Wind tunnel testing is a widely known form of testing that focuses primarily on the aerodynamics of a design by measuring the drag coefficient when a current passes over the surface of a vehicle. The less drag detected, the more aerodynamic the design and greater the efficiency.

However, fuel consumption testing has been to shown to be the fundamental metric used to measure fuel efficiency[c]. Fuel consumption is measured using SAE J1321 Joint TMC/SAE Fuel Consumption Test Procedure – Type II (SAE International 2012), which adheres to the following standards:

- Must involve a control vehicle and test vehicle(s).
- Control and test vehicle(s) must be identical, featuring the same engine, tractor, trailer and cargo.
- Researcher first must conduct baseline tests and fuel measurements.
- Test vehicle(s) then must be equipped with a variable (the technology being tested).
- Tests must be repeated and new measurements taken.

Employing these guidelines, researchers can use a comparison to the baseline test to physically determine how much fuel was used.

Hendrickson contracted an independent third-party test facility to conduct fuel consumption testing in order to study the performance of its AERO CLAD bumper vs. typical plastic bumpers with respect to fuel consumption. Tests were conducted by Performance Innovation Transport (PIT), a division of FPInnovations, at the Transport Canada Motor Vehicle Test Centre in Blainville, Quebec, as part of PIT's ninth Energotest event. Energotest is devoted to finding solutions that provide higher vehicle fuel efficiencies and lower emissions of greenhouse gases. During such events, PIT has tested nearly 50 technologies from various vehicle and equipment manufacturers. Hendrickson's objective was to compare the fuel consumption of tractor-trailers equipped with AERO CLAD front bumpers vs. factory-installed plastic bumpers.

Using SAE J1321 Type II protocol, the PIT researchers conducted three separate tests — each with one control vehicle and one or more test vehicles — to study what effect AERO CLAD bumpers may have on fuel consumption, as compared with the corresponding OEM-installed plastic bumpers.

The first test, conducted in the spring of 2012, utilized two Volvo VNL tractors1 and two trailers, respectively with the same general configurations except for one variable: the front bumper. The VNL control vehicle featured the OEM-supplied plastic bumper, while the test vehicle featured the Hendrickson AERO CLAD bumper with air dam model for VNL. All the vehicles were confirmed to be in proper operating condition before and during the tests. The second test, conducted in the fall of 2012, featured three Freightliner Cascadia tractors2 and three trailers. Once again, the respective vehicles had the same general configurations except for the front bumpers. The Cascadia control vehicle featured the OEM-supplied plastic bumper. The first test vehicle featured the AERO CLAD bumper with air dam model for Cascadia, and the second test vehicle included the same AERO CLAD bumper with air dam in addition to an extended belly pan. The third test was conducted on three ProStar tractors3. As in the previous tests, the control vehicle featured the OEM-supplied plastic bumper, while one test vehicle was equipped the Hendrickson AERO CLAD bumper and the other with the Hendrickson AERO GUARD bumper ALL vehicles were confirmed to be in proper operating condition before and during the tests.

In accordance with the SAE J1321 Type II protocol, testing compared the fuel consumption of a test vehicle operating under various conditions. Fuel consumption was accurately measured by weighing temporary fuel tanks before and after each trip. The repeatability of the scale measurements was periodically checked during the tests using a set calibration weight[d].

The fuel consumption tests were performed on the BRAVO high-speed test track located at the Transport Canada Motor Vehicle Test Centre, designed to minimize driver influence through high-banked turns and a parabolic oval shape. The track is 4 miles (6.4 km) long, and the length of a test run was 13 laps (87 km), with departure and arrival at the same position along the track.

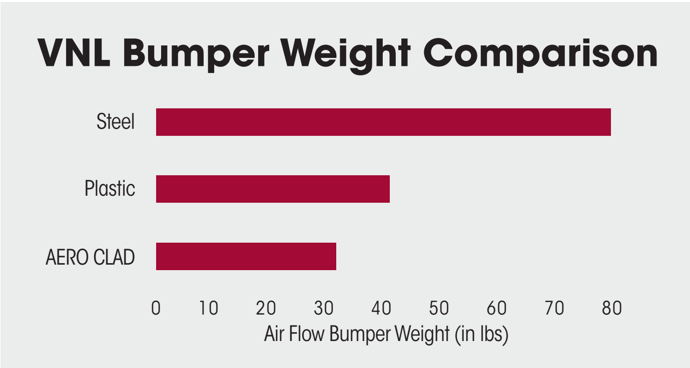
Additional measures were taken to eliminate driver influence and to ensure that all vehicles operated under the exact same conditions. The test vehicles were warmed up for the same amount of time at the test speed to help ensure the same vehicle operating conditions. Drivers started at maximum acceleration with a consistent cruising speed of 61 mph (98 km/h) set. After completing the test duration, drivers stopped using the cruise control at the exact designated point. During deceleration, drivers only applied service brakes and did not accelerate. Once the vehicle arrived at the stopping point, the tractors idled for the same duration before stopping engines.

Time and distance intervals between the two consecutive trucks remained the same in order to avoid the turbulence. In addition, two radar speed signs controlled the driving cycle by displaying the speed of oncoming vehicles to allow drivers to monitor speed periodically. Test personnel also recorded speed using a hand-held radar gun. Drivers were given instructions via radio to ensure consistent speed and distance during run durations, and the vehicles were equipped with global positioning system (GPS) units, which were used for checking vehicle speed and spacing control[d].

SAE TESTING RESULTS

Volvo VNL Summary

PIT reported the following in reference to testing conducted on the VNL with one control vehicle equipped with the OEM-supplied plastic bumper with air dam and one test vehicle with the AERO CLAD bumper with air dam: "The AERO CLAD bumper and air dam design from Hendrickson Bumper and Trim is lighter than the Volvo OEM bumper (18.6 kg compared to 22.3 kg for the original bumper), improves the appearance of the vehicle and offers better protection." PIT went on to confirm that there was no adverse effect on fuel consumption on the vehicle with the Hendrickson AERO CLAD bumper[d].



Freightliner Cascadia Summary

Testing conducted on the Freightliner Cascadia included a control bumper with OEM-supplied plastic bumper, one test vehicle with the AERO CLAD bumper and one test vehicle with the AERO CLAD bumper and air dam with belly fairing. Analyzing these results, PIT reported that fuel consumption was within the test measurement margin of error and also was not affected by the use of a Hendrickson-supplied AERO CLAD bumper with no air dam. Fuel consumption was greater, however, in the second case with airdam and belly fairing, which may be explained by increased frontal area compared with the original bumper[e].

Ground Clearance of Cascadia OEM Bumper Compared to AERO CLAD

Adding air dam to AERO CLAD bumper (right) reduces ground clearance advantage to 2.75″ on the Cascadia (left) but without the air dam has an advantage of 4″.

International ProStar Summary
The International ProStar tractor testing consisted of one control vehicle with the OEM-supplied plastic bumper, one test vehicle with an AERO CLAD bumper and one with an AERO GUARD bumper. Test results from PIT indicate the two bumpers from Hendrickson presented fuel consumption within the test margin of error and showed no influence on fuel consumption.

Ground Clearance of ProStar OEM Bumper Compared to AERO CLAD

The AERO CLAD bumper (right) compared to the ProStar OEM bumper (left) has a ground clearance advantage of 3.75″.

OVERALL SUMMARY
According to the SAE J1321 Type II protocol, test results from all prototypes supplied by Hendrickson Bumper and Trim expressed a confidence level of 95 percent. *In all of the tested scenarios, the addition of the AERO CLAD bumper "resulted in a statistically insignificant fluctuation and relatively minor increase in fuel consumption."* AERO CLAD did not sacrifice fuel efficiency in any of the test vehicles, while bringing improved features such as durability across all models and increased ground clearance in some. The AERO CLAD technology therefore emerges as a viable and attractive option in today's market.

Conclusion

Fleets worldwide are looking to improve operating costs through fuel efficiency and reduced maintenance expenses. Often the perception among these fleets is that a plastic bumper will provide weight savings and is more aerodynamic than its metal counterparts. While effective in reducing weight compared to traditional steel bumpers, plastic does not address the needs for increased ground clearance, durability and aesthetics.

Extensive research trials outlined in this paper have confirmed that replacing OEM-supplied plastic equivalents with AERO CLAD bumpers produced no significant adverse effect on fuel efficiency. But the bottom line is that AERO CLAD offers an alternative to heavier metal and weaker plastic bumpers since it does not degrade fuel efficiency or sacrifice durability. With a corrosion-resistant finish and greater ground clearance, AERO CLAD also reduces maintenance costs through fewer repairs due to paint chipping, corrosion of chrome and scratches/dents caused by varying operating environments.

An innovative fusion of aluminum and stainless steel with no statistically significant differentiation from plastic in terms of fuel efficiency, AERO CLAD speaks to the industry's entire body of concerns, maximizing savings in fuel without compromising durability and aesthetic. AERO CLAD is the solution for fleets that value a chrome-like finish, fuel efficiency, lighter weight and improved ground clearance.

For more information and a copy of the test results, call 800.356.6737 or visit www.hendrickson-intl.com/Bumper.

a "How Aerodynamics Work," howstuffworks.com, 2011

b "Ask an Engineer," MIT Engineering, 2010

c Technologies and Approaches to Reducing the Fuel Consumption of Medium- to Heavy-Duty Vehicles, National Academies Press, 2010

d Fuel Consumption Tests of the Hendrickson Bumper and Trim, L.L.C. AERO CLAD Bumper and Air Dam Design, FPInnovations, 2012

e Fuel Consumption Tests of Hendrickson Bumper Prototypes, FPInnovations, 2012

f Fuel consumption tests of Hendrickson Bumper Configurations from Hendrickson Bumper and Trim 2014

1 Truck model tested: Volvo VNL, built March 5, 2012

2 Truck model tested: Freightliner Cascadia, built January 10, 2012

3 Truck model tested: International ProStar, built February 14, 2014