Airtab

Attached Airflow; what is it, and why is it important to truckers?

Why is it important for vehicle designers to have airflow stay “attached” to vehicles whether it is an auto, van, straight truck, tow trailer or tractor-trailer semi? This paper will address definitions of attached and separated airflow and their application to Class 8 tractor-trailers. By extension, this discussion would also apply to all large, bluff bodied ground transportation vehicles that spend a majority of their drive time at highway speeds.

A “streamline” is a line that is parallel to the direction of flow of a fluid at a given instant or the path a given particle follows in a flowing fluid. A streamlined shape, therefore, is one that is constructed with a shape that offers a minimum resistance to fluid flow. Prime examples of streamlining are modern aircraft and just about any fish or sea mammal.

There are basically four main areas of a moving transport truck that create aerodynamic drag. They are the front of the vehicle, the tractor-trailer gap, the undercarriage and the rear of the vehicle. For the purposes of this paper and for simplicity, skin friction drag is omitted.

To achieve the maximum reduction in aerodynamic drag forces from the points mentioned above, a moving vehicle needs to punch the smallest possible hole through the air and leave the smallest wake behind.

There are two types of airflow that occur on all vehicles; Attached Flow and Separated Flow. As far as is practical, vehicle designers strive to keep the flow of air as close to the vehicle skin as possible. This is attached flow, and from an aerodynamic streamlining viewpoint, it is much more preferable than separated flow.

Attached Flow occurs when air naturally flows quite smoothly over the surface contours of a moving body. However, if that Attached Flow encounters an excessively sharp corner, bend radius or blunt object in the body shape, it breaks free of the surface and becomes wildly chaotic and turbulent. Once that happens, the airflow no longer follows the contours of the body shape. This chaotic, turbulent flow is called Separated Flow.

Why is attached flow “better” than separated flow?

Separated Airflow is turbulent air and turbulent air increases drag. When Separated Flow is created it effectively expands the size of the hole the vehicle makes as it passes through the air by adding to the dimensions of the sides, the top and the undercarriage so that aerodynamically, it is larger than it physically is. The vehicle punches a larger hole through the air. This requires more energy and therefore more fuel to move it through the air than if the airflow was attached.

Separated Flow is worsened by sharp corners (both horizontal and vertical) on the front of the tractor or trailer, and by obstacles mounted on the vehicle that “sticks out” into the airflow. These include objects such as bug deflectors; exhaust stacks mounted outside of fairings, breathers, running lights, air horns, mirrors, handrails, landing gear etc. Trailers that have square corners rather than a rounded corner or that have external vertical structural members that protrude from the side of the trailer also cause separated flow.

Separated flow is also caused by crosswinds.
In no wind conditions, separated flow caused by the tractor usually reattaches to the sides of the trailer about 1/3 of the way back. With a strong crosswind, the flow on the "downwind" side of the trailer may never reattach. In addition, real life crosswinds come in gusts and this variation in wind forces caused by the gusts facilitate the formation of separated flow.

An example: Imagine a tractor with a full “condo” fairing hauling a small tanker trailer with a 50-60 inch gap. Besides the frontal “profile” drag from both the tractor and trailer (due to the large gap) there is excessive separated flow occurring as the air tries to round the trailing edges of the tractor fairing. This turbulent airflow would most likely never “re-attach” to the trailer due to size differential and the ladders, walkways and plumbing that are integral with tanker trailers. Ways to reduce separated flow in this example would be to reduce the frontal area of the tractor if possible, to more closely match the frontal size of the trailer with the tractor and, to reduce the gap dimension. Ideally, separated flow would be further reduced if there were no gap at all, and the tractor and load was one continuous unit.

As this is not the case, the smallest practical gap yields best aerodynamic results.

Expressed another way, separated flow causes additional drag because the turbulence along the trailer's sides and roof is very much like additional vehicle frontal area.

That effective increased frontal area creates drag that is *in addition to* base pressure drag (suction) that exists at the rear of every trailer.

Another example; the vertical external ribs on a trailer or dump truck will keep the airflow permanently separated on the sides and cause the vehicle, from an aerodynamic viewpoint, to look wider than its physical dimensions.

As mentioned above, this effective increased frontal area creates drag that's above and beyond base pressure drag (suction) that exists at the back of all square back trucks and trailers, even ones with attached airflow.

Q. If the air separates at the tractor, what are the factors that affect where or if the airflow will re-attach or separate again from the trailer.

A. There are many factors. They include:

a. The severity of the initial separation. How aerodynamically friendly or streamlined is the unit. Does it have external stacks, breathers, running lights, air horns etc. sticking out into the air stream? Is it a long haul unit (eg a Volvo) or a work truck (eg Western Star) These factors will affect the degree of flow separation.
b. The gap size. The smaller the gap, the less turbulence behind the power unit and the quicker the reattachment of the airflow along the trailer sides.
c. Does the trailer have generous radius curves or large rounded corners at the leading edges of its sides? At highway speeds, any corner curvature with less than a 6-inch radius contributes to the formation of separated flow. Similarly, the ordinary 90-degree sharp edge between a trailer's roof and its side creates drag during side winds. Airflow spilling from the roof onto the side (or visa versa) will separate. Radius corners between roof and sides let the air flow either way and remain attached. Commercial van trailers don't offer a choice

here, but travel trailers and motor homes do. Always choose one with rounded upper edges over the full length of the rig for the lowest aero drag.

d. The type and size of the load hauled. Is it a smooth sided 53 ft van or a cattle or grain hauler? Is it a tanker with a lot of hardware sticking into the air stream?
e. Wind conditions. Gusty crosswinds, land features, other road vehicles all combine to degrade the attached flow environment surrounding a moving truck.

Of the factors listed above, most are not at all changeable by drivers or fleet owners. Not much can be done about wind, weather, geography, client location, route structure or "fellow travellers" with whom we share the road. Striving to spec and run vehicles that are aerodynamically friendly, those that facilitate attached airflow as much as possible yield fuel saving results each time they hit the road.

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