///Race Louvers

Professional R&D - Wind Tunnel Tested - Track Proven

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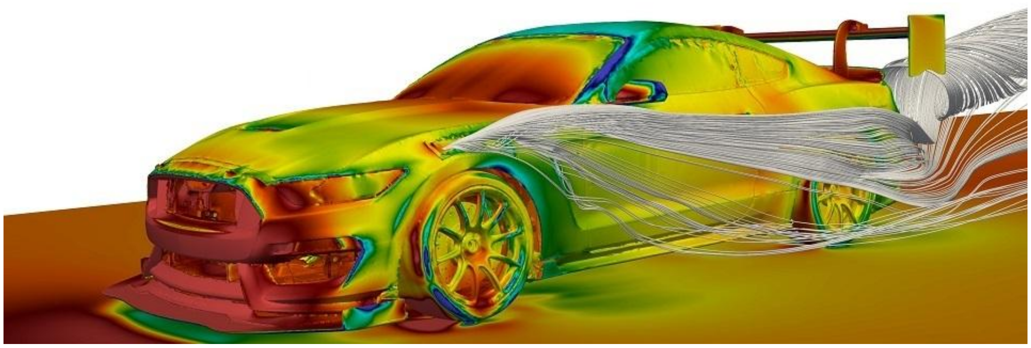

Tech Tips

Welcome to Race Louvers. We put this tech tip document together to help the car enthusiast community understand the principles behind aerodynamics, specifically hood and fender extractors and how to effectively implement their use. This information was gathered via extensive wind tunnel testing, cfd testing, track testing and development testing. We intend to regularly update this so check back often.

Aerodynamic Data and the Internet: Aerodynamic data comes in many forms, drag, lift, downforce, lift/drag ratios, aero balance front to rear, heat exchanger differential pressure, etc. As you may be aware, the internet can be good, bad and everything in between. Ie. Testing parts on an actual car yields the most accurate data, testing parts in free stream air without a car yields very inaccurate data, so look into how the part was tested. Since aerodynamic forces quadruple when speed is doubled, some companies will use higher speeds like 150mph to show higher aero numbers to promote their products but the reality is most turns at the track where you actually need the aero are in the 80-120 mph range. The point is do your homework, dont rely on hype, avoid the companies that over sensationalize their products, read into the data, is their actual data, how was that data gathered, what was the setup, etc.

CFD Testing: CFD Is a simulation of the real world. In the hands of professionals it is a powerful tool however in the hands of amateurs it can be highly innacurate. In order to net accurate results parts need to be tested on cars and not in free stream air. This requires scans of the vehicle's exterior, underbody, wheel well, front grill and engine bay and are critical to accuracy. Remember air flows over the car, under the car and through the car. Use of an external vehicle scan only and CAD modeling of the engine bay or fender wells for example instead of actually scanning it means your CFD model is no longer a true representation of your actual car and this leads to very inaccurate data or data that is not representative of the actual car. To take things further CFD, computational fluid dynamics, requires assumptions and data input from the user and this is an area where a person with little to no aero background or simulation experience can get it wrong or worse manipulate the input data to effect the outcome netting data skewed in their favor. So if CFD is your thing, look for the data not just a fancy image, how was the part tested, what scans did they use, and most importantly who did the testing, was it some DIY’er on instagram, or was it someone from Formula 1.

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Wind Tunnel Testing: Wind Tunnel testing is a powerful tool. It allows for entire vehicles and parts to be tested in real world conditions in a controlled environment netting highly accurate results. Data for downforce, drag, radiator airflow, brake duct airflow, lift-drag, aero balance etc is displayed in real time. Parts can be easily swapped for back to back testing against other parts or no parts for baselines. Since there is no programming, software setup or scans required, the users only control of the data is by actually changing the vehicle's setup via parts on the car.

CFD vs Wind Tunnel: Both are extremely useful tools if in the hands of professionals, expensive and typically left to product manufacturers or professional race teams.

Track Testing: Track testing is another option but variables such as ambient temperature changes, track condition changes, lap traffic, tire degradation all make it hard, track testing is more about dialing in the mechanics of the suspension after the aerodynamics are optimized.

Part Testing in General: Look for the actual data. Just because you see a vehicle in CFD or in the Wind Tunnel with a part on it doesnt mean they actually tested the part. In order to test a part and get useful data you need baseline data without the part and then data with the part. Getting test data of another part for comparison will show how good or bad the part functions and not just that it functions.

Bernoulli's Equation: Simply put the relationship between air velocity and air pressure, *high flow - low pressure* VS *low flow - high pressure*. No need to get into the scientifics of this but only to remember the relationship between flow and pressure. If airflow was to increase the air pressure will decrease, if airflow were to decrease the air pressure would increase.

Purpose of hood venting and extraction: The main reasons for hood venting are to increase heat exchanger cooling (radiator), reduce engine compartment temperatures and to provide front downforce (reduced lift).

Purpose of fender venting and extraction: The main reasons for fender venting are to increase front downforce (reduced lift), improve front brake cooling and to help heat exchanger cooling (radiator).

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Venting or Extraction? Whats the difference? This is a matter of semantics. Venting simply put is the relief of pressure. Most hood vents on the market function as a vent, they simply allow high pressure air to flow to a lower pressure area, typically from under the hood to the top of the hood. Extractors also vent high pressure air to a lower pressure area but if designed properly will also create a much lower pressure area above the vent further enhancing airflow thru the heat exchangers and out from under the hood.

How to improve cooling via venting/extraction: There are two basic ways to improve cooling, increase the size of the heat exchanger or increase the airflow thru the heat exchanger or both. Traditionally air exiting the radiator flows down and out under the car. Adding another exit path properly located on the hood allows air to also flow up and out improving airflow thru the radiator and cooling. Further, adding another exit path on the fender improves flow thru the fender well which improves airflow thru the lower radiator, brake ducts if equiped, cooling both the engine and brakes.

How to improve front downforce via venting/extraction: Downforce or lift generated by a vehicle is directly related to the pressures acting on its surfaces. Per Bernoulli's equation above if air velocity is increased its pressure decreases and if the air pressure under the hood relative to the air pressure on top of the hood is reduced, lift is reduced and downforce is generated. Also airflow thru the grill and airflow under the front bumper merge around the firewall area and exit under and behind the car, this merge slows the airflow both thru the grill and under the front bumper, adding hood extraction allows the airflow thru the grill to exit up and out increasing airflow and improving cooling while airflow under the front bumper speeds up increasing front downforce and if equipped with a splitter allows the splitter to work better thus creating more front downforce. Better hood vent = better cooling = more downforce potential.

Extractor location: This is very important. The main purpose of a hood vent or extractor is cooling, heat exchanger cooling ie rad/oil coolers etc, the secondary purpose is downforce. So to improve cooling one can improve the airflow thru the radiators, this can either be increasing the pressure in front of the radiator (bigger grill opening) or decreasing the pressure behind the radiator (bigger opening behind the rad) to net a larger differential pressure across the radiator core, more differential pressure = more airflow = more cooling. So with regard to vent placement the front should always be right behind the radiator with the rear no closer than about 1/3 of the hood length from the windshield. If the vent is forward of the radiator the air exiting the radiator has to do a 180 turn up and forward to the vent and another 180 turn up and out of the vent

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which is highly inefficient or worse yet a vent forward of the radiator may steal air from the front of the radiator hurting cooling. Why 1/3? With under hood pressure as a reference, generally the front of the hood is a lower pressure zone, the center near zero and the rear a higher pressure than the engine bay. So with no vent the zero differential pressure point on the hood's surface is about 1/3 the way from the glass so say your hood is 48" long then the zero diff press point on the hood is roughly 16" from the glass. Now this high pressure zone on top of the hood is generally in the center, as you approach the A pillars the zero diff press point on the hood is very close to the A pillars, just a few inches, so center vents need to be pretty far from the glass but side vents can be much closer. Vehicle speed generally determines how big the center cowl high press zone is. Now once you add a hood vent everything changes. The first thing is the engine bay pressure gets lowered, this changes the zero diff press point on the hood 1/3 way from the glass to further forward. The better the hood vent or extractor the lower the engine bay pressure the further forward the zero diff press point on the hood is. Next the vent adds pressure to the top cowl area even further moving the zero press point forward. This zero diff pressure point dictates the location of the back of the vent. So our general rule of thumb for Race Louvers is 2" behind the rad to 20" from glass in the center, 15" on the sides and 6" for top mount fender vents give or take and as wide of an extractor(s) as you can get on the hood. This is why our Race Louvers aren't quite as long as some of the other companies.

Size Matters: Extractor and vent performance is directly related to their design and physical size. Not only have we documented our Race Louver designs as well as competitors designs, we have documented size vs performace. As an example in the wind tunnel we tested our single RX trim 24”x14” extractor totaling 350sqin vs both the 24”x14” RX trim center and a 19”x7” RX trim side extractors combined for a total of 585 sqin for a 67% size increase. The center kit yielded 38lbs of downforce while both kits yielded 62lbs for a 63% increase. So bigger is better so long as they are behind the radiator and not too close to the high pressure cowl area.

Heat exchanger differential pressure and flow: In order for a heat exchanger to transfer heat to the surrounding air there must be a surface area and airflow over that surface area. Increasing the surface area and/or airflow increases heat transfer. Air flows from high to low pressure zones. To increase heat exchanger airflow one must increase the high pressure in the front or decrease the low pressure in the rear or both. Opening up the grill size is common and will increase the front pressure for improved cooling but creates lift via the added pressure. Adding hood or fender extraction decreases the rear pressure improving cooling while adding downforce via the lower pressure.

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Ducting the radiator to the front grill: Ducting the front grill to the radiator involves making top, bottom and side panels that connect the front grill opening to the radiator and other heat exchangers. This prevents air entering the grill from going around the heat exchangers and forces the air to go thru maximizing the use of the air entering the nose. While fancy sheet metal curved ducts work great, simple top, bottom and side sealing panels will get you most of the way there, in fact canvas ducts are a great option because they seal well and can survive some front end contact without puncturing the radiator. Most modern cars have some panels from the factory so keep them or add better ones but removing them will only hurt cooling.

Gurney Flaps & Wickers: Wickers or gurney flaps are components placed on a vehicles surface perpendicular to the airflow. They disrupt the airflow causing a higher pressure in the front and lower pressure behind. Wings commonly use these to improve performance. They also help in hood extraction but the overall vent design must work with them to realize optimum performance. If a wicker is used in front of a vent it creates low pressure behind it as well as high pressure in front of it and if the vent design behind it is highly restrictive and or can't make use of the low pressure then there will be little cooling airflow increase or downforce gained but a large increase in drag. We have wind tunnel tested several gurneys on competitors vents with mixed results, the best we have seen showed small gains in cooling but also added drag while the worst we have seen has shown no gains in cooling and a large increase in drag so we recommend not blindly adding gurney flaps to your hood or fender vents.

Lift to Drag Ratio: Lift to drag ratio is a common way to look at the efficiency of a wing or vehicle. A wing uses some energy (drag) to create lift (downforce) and is pretty straight forward. With regards to hood extraction one needs to consider that drag nets two gains, cooling and downforce. A vehicle uses some energy (drag) to counteract lift or create downforce however in the quest for optimized vehicle lift to drag the required cooling air entering the radiator is often not accounted for leading to good lift to drag but not enough cooling to run the vehicle so keep in mind there is always a balance of aero and cooling.

Downstream Effects of Hood Extraction: Hood venting and extraction has little to no effect on downstream aero devices such as the rear wing. We have seen less than a 5lb variation in rear DF at 100mph in the wind tunnel from hood venting and that variation has more to do with the leverage effect than creating dirty air for the rear wing.

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Leverage Effect: The leverage effect is a result of aerodynamic devices located forward of the front axle centerline and rear of the rear axle centerline. Adding a front splitter forward of the front axle centerline creates front downforce and rear lift. Adding a wing aft of the rear axle centerline creates rear downforce and front lift.

Grill blocking basics: Grill blocking is simply a means to restrict the size of the grill opening which will restrict the amount of air entering the heat exchangers. The better the hood extractors the more grill restriction you can add the more front downforce you can achieve. For vehicles with an upper and lower grill opening its best to retain them both and restrict each one, this provides an airflow path thru the top of the exchangers and out the hood as well as thru the bottom of the exchangers and out the bottom of the car. This also allows the user to effect temperature changes for different exchangers that may be located in one opening or another which allows some balancing of temps between the coolant, oil or trans. If you have a fancy curved inlet duct commonly seen on race cars then one lower opening is best. Tape, plastic panels etc all work well as blockers. Determining the blocker size is simple, add some tape, run the car and note temps, add more tape as needed until the temps rise higher than the thermostat rating and you know the limit.

Fans, shrouds and flaps: The purpose of a fan is to provide cooling airflow thru the radiator at little or no vehicle speed. The purpose of a shroud is to match the size of a round fan assembly to a square radiator so that air can flow thru the entire radiator core instead of just a small round section by the fan. While shrouds are great when the fan is on and at low vehicle speeds it becomes restrictive at highway speeds and even more restrictive at track speeds. Flaps are one way doors that allow additional air to flow thru the radiator when the vehicle is at speed making the shroud less restrictive but close when the vehicle stops allowing the shroud to do its job. Further fan shrouds add drag to the vehicle. So while fans and shrouds are great for street cars, dedicated track cars fare better with no fan or a fan with no shrouds. We have found that a single slimline electric fan without a shroud to be the best setup for dual purpose cars as they offer a fan for low speed cooling but little restriction for high speed track use.

Radiator, Intercooler & Oil Cooler Stacking: The stacking of heat exchangers can be a challenge. We already know the key to cooling is heat exchanger surface area and airflow thru it and in order for air to flow there must be a pressure differential. In theory the best setup is to have all the heat exchangers side by side so they each have their own air entry and exit thru them however due to packaging within the front of a vehicle this is not generally possible. This leads to the need to stack exchangers in front of one

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another. While this is common and works reasonably well there are some things to keep in mind. First is each cooler must be sized appropriately per the heat load on that system, if one system has too large of a cooler then it will cool great and the other systems will suffer, ie too big of an oil cooler. Second, generally you want the coolest exchanger up front and the hottest exchanger out back, ie intercooler up front, then radiator then oil cooler although its common for everything to be in front of the radiator as the back has fans on it. Third, if you are stacking coolers there must be little to no gap between them. If there is a large enough gap then air pressure behind the cooler will increase almost to the point of the front pressure causing no differential pressure and no flow thru it reducing its effectiveness.

The Cooling System: The cooling system has two main areas, coolant flow to transfer heat from the engine to the radiator core and airflow to transfer heat from the radiator core to the surrounding air. There are many components in the cooling system and cooling is only as good as the weakest link, ie the best radiator in the world will not function well without sufficient airflow thru it.

Coolant & Oil Temperatures: It is important to have the proper temperatures, if the temps are too low you are wasting energy over cooling the car, if the temps are too hot there is a risk of damage. Typical track temperatures are about 200-225F coolant and 250-275F oil. Coolant temps are much more important than oil temps as bad things can happen quick, blow a head gasket, water boil over and in the modern world loss of speed due to the ecu pulling power to save the motor. Oil temps on the other hand are much less of a concern as the main issue is oil thinning with elevated temps which is easily cured by running a thicker oil, ie switching from 5w-20 to say 5w-40, this kepts the viscosity higher while at higher temperatures.

Thermostats: The only purpose of a thermostat is to hold a minimum temperature in an engine. They have no other effect. Typical thermostat ratings are about 195F. If your car is running hotter than the thermostat rating, then the coolant temp in the radiator is just as hot and changing to a lower tstat rating will not lower the temperature. In order to lower the temperature the reserve coolant in the radiator needs to be cooler than the engine. Thermostats also have an operating range of about 15 degrees, meaning the rated temperature is the temperature at which it starts to open and is typically not fully open until 15 degrees hotter, so a 195F Tstat starts to open at 195F but is not fully open and free flowing until about 210F. In regards to hood venting and cooling the thermostat can mask cooling gains from the addition of vents. If a 195F tstat is used and the coolant temps are running 195-210F then you will not see much if any temperature

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reductions as the tstat will be controlling the minimum temperature. If you car is running 230F with a 195F then temperature reductions will be clearly seen.

Tuft Visualization: Tufts are pieces of string or yarn usually 1-2” long that get taped to a vehicles surface and are a great airflow indicator. While they dont show any quantitative data like downforce or drag they do show flow direction, attached and detached flow. When used as an indicator for hood vent functionality one needs to remember these are velocity driven, in other words a small hood vent will have higher air velocity exiting the hood then a larger hood vent. This makes the tuft appear standing taller or more energized in a small vent vs a larger vent even though the larger vent works better due to the volume of exiting air not its velocity. So while these are good indicators they dont provide any quantitative data.

Gear Oil Visualization: This is an easy to do trick to seeing airlfow direction over a vehicles surface. Simply get a Q-tip, dip it in gear oil and place a drop on a vehicles surface, drive the car and then stop and see the results.

Smoke Visualization: Smoke wands are used in the wind tunnel to show how air flows over, around and thru a vehicle. While this doesnt provide quantitative data it helps with a visual understanding.

Pressure measuring equipment: Instrumentation used to measure pressure such as manometers or magnehelic gauges are often misused by people resulting in inaccurate data. While the gauges themselves are reliable its the probes or lack thereof that cause the issue. Using a manometer and an open ended tube to measure pressure is only accurate for static pressure (no flow) and highly inaccurate within an airflow stream. Measuring pressure within an airflow stream requires specialized probes. For example the aerospace industry uses dynamic pitot tubes to measure pressure in an airflow stream but these are only accurate if parallel to the air stream. So specialized probes for measuring air pressure in non-parallel turbulent air streams typically seen within the engine bay are a must for accurate data.

Pressure Mapping: Pressure mapping is an outdated practice to see localized pressures around the vehicle specifically on the hood for hood vent location. Generally the hoods top pressures are low pressure towards the front of the hood, near neutral pressures in the middle and the well known high pressure zone at the back of the hood by the cowl. This holds true for pretty much all vehicles. With regard to different vehicles, we have mapped many and while they are slightly different car to car they are extremely similar with regards to venting, same nose, same hood, same vertical front

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mount radiators, same angled windshields. We have also mapped the same vehicles after extractor installation as everything changes once a hole is cut in the hood. So while many think this is the go to method for hood vent location it is NOT. Hood vent location is all about the airflow path thru the radiator. This means airflow in thru the front grill, thru the radiator and up and out the hood. This means the hood vent location needs to be right behind the radiator. Pressure maps on many vehicles show a low pressure area at the very front of the hood most of the time this location is in front of the radiator and putting a hood vent in front of the radiator is counter productive. So, hood vent location is right behind the radiator but not too close to the high pressure cowl area.

Fender Extractors & Fender Liners: When using our fender louvers if front downforce is the primary goal then the fender liner should remain and a hole should be cut in it near the louver, this maximizes front downforce but still provides some cooling. If the primary goal is improved cooling then the front of the fender liner should be removed as well as a hole should be cut in it near the louver, this maximizes cooling but still provides some front downforce

Gaps in the nose: Gaps in the front bumper cover, around the headlights, etc allow air to enter the nose, bypass the heat exchangers and pressurize the engine bay, this increase in pressure creates lift and also reduces cooling as the differential pressure across the heat exchangers is reduced. So try and keep the gaps sealed.

Hood Structure: OE Hoods generally come with significant structure below the skin and much if not all of the structure in the center of the hood can be removed without negative effects. However, when removing hood structure the perimeter, latch and hinge support structure should remain unaltered. If altering these we recommend hood pins be used.

Splitters & Skid plates: The natural cooling airflow path on vehicles is in thru the grill, thru the heat exchangers and out the bottom of the car. When adding splitters or skid plates that extend rearward of the radiator they block this natural cooling airflow path reducing cooling. If these will be used good hood extraction should be considered.

Rain / Rain Guards: Engine compartments and components are weather resistant and are designed to be in a 'wet' environment so rain guards are not needed. Further rain guards will restrict airflow and reduce performance.

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Cold Air Intake Kits: We recommend sealed cold air kits. This allows for cold air intakes and hood extractors to co-exist without a potential water issue. However if a cold air intake that uses the hood as a top or an open filter is used it should not be installed directly under the louvers. If you have an open filter cai kit already and a vent is to be installed directly above it, a hydrophobic pre-filter such as an InGen or K&N are an easy solution. These pre-filters will repel water while allowing air to pass through helping to avoid any potential water issues.

Louver angle in relation to airflow: Airflow over louver blades should be perpendicular for proper functionality. We have found airflow over a hood or fender is generally straight back front to rear so louvers should be installed perpendicular to this flow, angling louver blades for aesthetics beyond about 15 degrees to airflow will reduce functionality. So while there is some room for adjustment when installing louvers its best to avoid excessive install angles.

Ram Air Hoods: Functional ram air hoods such as the Subaru WRX's or any other ram air hoods should not put vents in front of the ram air inlets as this will negatively impact performance. If a vent was placed in front of a Subaru WRX hood scoop inlet then hot air from the radiator would be fed to the intercooler reducing its cooling ability.

Cowl Induction: On cars equipped with cowl induction where the engine air is pulled from the cowl area at the base of the windshield it is desirable to have a two piece center hood extractor kit with about 4-6" of space between them. This allows the heated air extracted from the engine bay to go around the cowl area while the gap in the middle feeds cool fresh air to the cowl area. This keeps the intake charge temperature as cool as possible for maximum horsepower.

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