

Undertrays, Spoilers & Bonnet Vents, Part 1



All modern car designs have spent thousands of hours in the wind tunnel while the engineers refined and altered, tested and assessed. But contrary to popular belief, many of those hours weren't used to create a body shape with great drag and lift figures. Instead the engineers were spending the time optimising the cooling system airflows - making sure that plenty of air reached the radiator(s) and could then leave without obstruction.

The average modified car is very different. Perhaps there's a randomly designed bodykit in place and there might also be added bonnet (hood) vents. But there's invariably not a lot of rhyme or reason to it all - sometimes directional vents are put in backwards, while others intended to let air in are almost certainly letting air out. Aftermarket undertrays? Well, while there's plenty of discussion on web groups about them, fitting and then testing their effectiveness is almost unknown.

So is it possible to design, install and test front aero aids that achieve something that's worthwhile? It sure is. In this series we take a detailed look at designing and fitting a front undertray, front spoiler, and bonnet vents. These were aimed at improving the airflow through the front heat exchangers – radiator, oil cooler, air con condenser, intercooler and power steering cooler. (In this article we'll concentrate on intercooler flows, but the others apply just as much.)

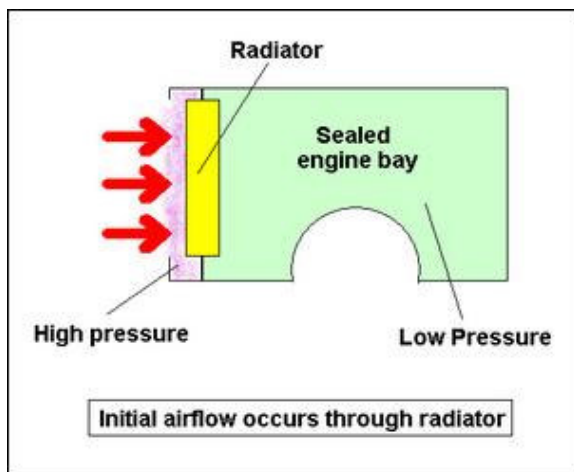
The whole exercise proved to be a learning experience in more ways than one - like finding out that at some speeds, the guinea pig car's underbonnet intercooler had in fact, zero outside airflow through it... Surely not? – but that's the truth.

But let's start at the beginning.

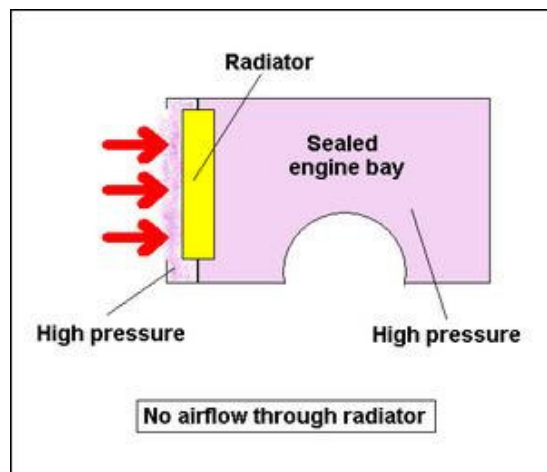
Pressures

Air will only flow if there is a pressure differential. This is a really important point to grasp – air doesn't pass through the radiator just because the car is moving forward. Instead, there needs to be a higher pressure in front of the radiator *and a lower pressure behind it* – that is, a **difference** in pressure.

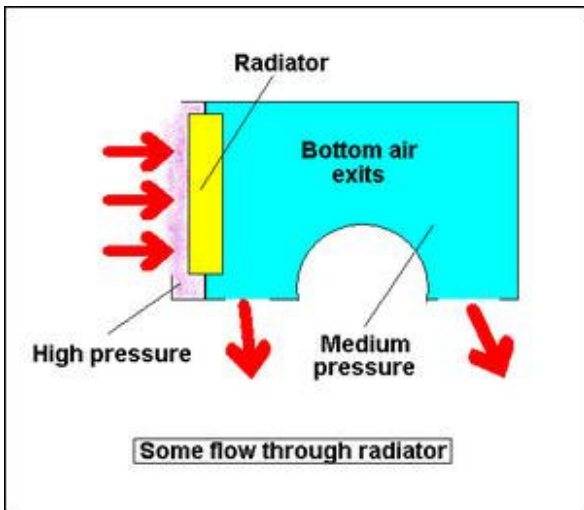
To better understand this, imagine that the engine bay is sealed off top and bottom. (In most cases it **is** sealed off at the top by the bonnet, but there are usually openings around the engine to allow air to flow out under the car - but here we'll think about a car with a totally sealed engine bay.)



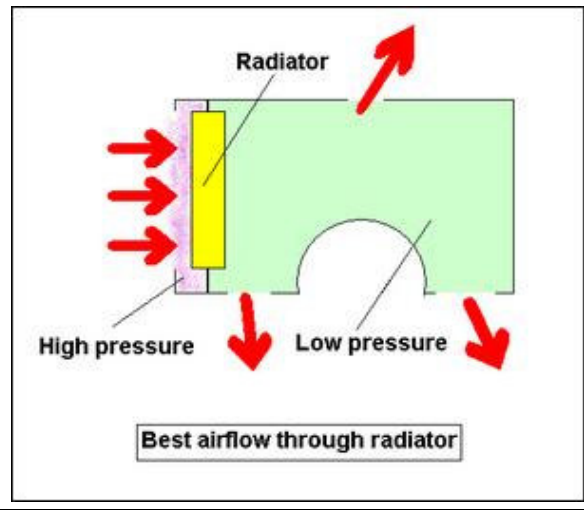
The car with the sealed engine bay moves forward and air initially flows in through the radiator.



However, without any escape route, the engine bay soon 'fills up' with air, until the pressures either side of the radiator become equal. Now, no more air will flow through the radiator.



With the normal openings beneath the engine, some air can flow out. The pressure build-up in the engine bay is therefore reduced, although it may be still higher than ambient.



With extra exit vents in the bonnet preventing any build-up in engine bay pressure, best flow through the radiator is gained. (Of course, you can substitute 'intercooler' or 'oil cooler' for radiator, if in fact their exit flows are also into the engine bay.)

So the airflow through a radiator doesn't depend on the pressure in front of the core; it depends on the pressure **difference** across the core. IOTW, the air exit is just as important as the air entrance – if the air exits aren't big enough (or the airflow doesn't pass through them quickly enough), pressure will build up on the downstream side of the heat exchanger, decreasing the flow that's occurring through it.

In this application, the primary purpose of front spoilers, undertrays and bonnet exit vents is to lower the pressure build-up inside the engine bay, so increasing the pressure differential across the heat exchangers (rad, intercooler, etc).

Intake Vents?



Bonnet entrance vents – eg to an intercooler – are located and shaped to build-up a positive pressure on one side of the heat exchanger. For example, this Impreza WRX uses a very large forward-facing scoop to cause increased air pressure on the top surface of the intercooler. If at the same time there is a lower pressure on the other side of the 'cooler, air flows through it. However, this in turn directs more airflow into the underbonnet space, creating an even greater need for a lot of exit flow capability.

So if you've added a bonnet scoop to pick up air – or you have enlarged the standard scoop – it's quite possible that there's a pressure build-up under the bonnet which is dropping the efficiency of your radiator, intercooler, oil cooler and/or air-conditioning condenser.

Get rid of that pressure build-up and all of the above will work better...

Measuring Instruments

This discussion of pressures rather than flow all sounds very scientific – "I am sure he's right, but what the hell?" However, when I tell you that it's very easy to actually **measure** these pressures on a moving car so you can see what's really going on, it all becomes a heap more relevant.

There are two instruments that can be used to measure these pressure variations. One is a Magnehelic gauge and the other, a manometer. (You can't use a normal pressure gauge like a turbo boost gauge because the pressures are very small.)

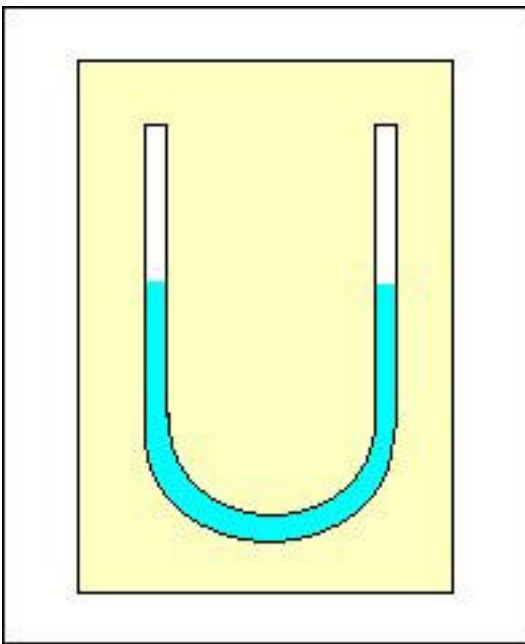


Magnehelic gauges are made by the US Company, Dwyer. They are designed to measure both positive and negative pressures, and so have two measuring ports. By using both ports simultaneously it's easy to measure pressure differentials – just what is wanted in this application.

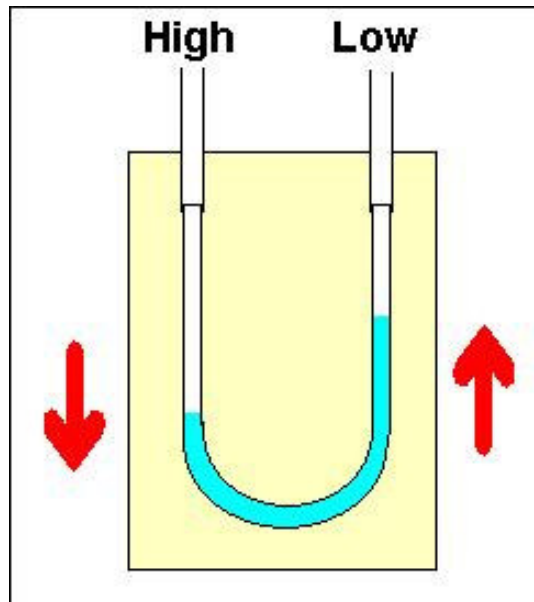
Magnehelic gauges can be bought new from Dwyer, or alternatively, secondhand. eBay is a good way of buying these gauges very cheaply – expect to pay about US\$15-25 for one. When buying a Magnehelic gauge, select a gauge that measures up to a maximum of about 3 inches of water. (The 3-inch gauge lets you use it in other applications as well – see below. If you intend using it purely for aerodynamic work, buy a 0-1 inch gauge like the one shown here.)

Other Uses?

Magnehelic gauges are extremely useful in car modification. They can be additionally used to measure flow restriction throughout the intake system, including pressure drops across intercoolers and the air filter. For more on these techniques, do an AutoSpeed site search under 'Magnehelic'.



Instead of a Magnehelic gauge you can use a water manometer. A manometer simply consists of a U-shaped clear plastic tube, partly filled with a liquid (usually water with food colouring in it). You can easily make your own by using some plastic hose and a plywood or particle board backing.



To make the

Each arm of the manometer is connected to the pressures being measured. The fluid in the manometer then moves in response to this pressure difference – the more it moves, the greater the pressure difference. The actual pressure change can be indicated by measuring the difference in height of the two fluid columns. For example, if their levels are vertically 1 inch apart, you are measuring a pressure differential of 1 inch of water.

manometer more sensitive, you can incline it at a fixed angle. If the manometer is angled at 30 degrees from the horizontal, a difference in level of 1 inch (measured along the tubes) becomes an actual 'inches of water' measurement of 0.5 inches. In this way, very small pressure differences can be easily read off, even in a moving car. (Of course, you should use an assistant to read the manometer.)

Note that while I have spoken throughout this series of measurements in inches of water, it's usually not worth making the measurements in actual units – it's a lot easier to just put arbitrary markings on the manometer backing board so you can see relative changes.

The only downside of the home-built manometer is that its orientation must be kept fixed (eg vertically or at a constant angle) and very small pressure differences are hard to measure.

More on Manometers

- U-shaped manometers are also commercially available. Some use liquids that are less dense than water, so providing an expanded scale that still reads in 'inches of water'.
- Make sure that the pressure differential is never so great that the water all ends up in one arm of the U-tube. If this occurs, you need a taller manometer with more water in it.

A home-built manometer can be a very sensitive instrument, capable of showing pressure differences of just 0.01 psi. So despite the simplicity of the instrument, don't think for a moment that it is a poor relation.

Making Measurements

The first measurements that you should make are of the pressures under the bonnet. Leaving one arm of the manometer open to the pressure inside the car, connect a tube from the other arm to the underbonnet area. You can temporarily stick the open end of the tube to the underside of the bonnet with masking tape. If you are using a Magnehelic gauge, connect the sensing tube to the 'high' port and leave the other port open.

Then drive the car and watch what happens on the measuring instrument.



On the guinea pig car – a Nissan Maxima V6 Turbo with an added bonnet scoop for the side-mount intercooler – the underbonnet pressure rise was considerable. For example, at 80 km/h there was no less than 0.4 inches of water pressure build-up in the engine bay. Given that we have previously measured a pressure in the intercooler scoop of 0.4 inches of water at this speed, it looks very much like the air movement through the intercooler (without the intercooler fan working) is zero. That's because the pressure either side of the intercooler core is the same.

It's worth repeating that: first measurements indicate that the Maxima's underbonnet intercooler is getting no outside airflow through it when its fan isn't running, even at high road speeds. OUCH!

You can see why all this stuff is pretty damn' important to car performance...

Next week: testing, building and

Undertrays,Spoiler & Bonnet Vents, Part 2

In this article we'll be installing an undertray/spoiler that dramatically and measurably improves underbonnet intercooler and radiator efficiency.No,you don't need a wind tunnel like the one above-just a cheap measuring instrument,some cardboard and sticky tape,and your local roads.



Last week [Undertrays,Spoilers & Bonnet Vents,Part 1](#) we introduced the idea that before air can flow,a pressure difference is needed.So for example,before air will pass through an intercooler or radiator,there needs to be a higher pressure on one side than the other.Even if the pressure is high on the front face of the radiator or intercooler,if it's also high on the back face,no air will flow through it.

In short,air exits are just as important as air entrances.

In Part 1 of this series we left you with the information that the measured pressure increase on the front face of the guinea pig Maxima V6 Turbo's underbonnet intercooler(air channelled to it by a bonnet scoop)was pretty well matched with the air pressure in the engine bay...which is where the intercooler air exit is.

Of course in this situation,no airflow through the intercooler will be occurring....

Starting Point



The whole desire to make some aerodynamic changes to the front of the car came about because when doing some other road testing,I'd had the standard undertray off the car.This design is in two small pieces,with one section hanging down low at the rear.I'd already found that when this undertray was tied upwards,the measured intake air temp rose as intercooler efficiency dropped(see [Driving Emotion](#)).But with the undertray removed completely,the performance of the intercooler and radiator seemed to go even further backwards.

It therefore seemed that some tweaking of the undertray had the potential to dramatically improve intercooler(and perhaps also radiator)efficiencies.But at this stage I had no idea what I was getting into –the data subsequently proved to be absolutely startling....

Underbonnet Measurements



Using a Dwyer Magnehelic 0-1 inches of water gauge(see last week's story for more on these gauges)I made measurements of the pressure under the bonnet of the Maxima.Two measuring locations were picked:

- against the underside of the bonnet,basically in the middle of the panel towards the rear
- near to the intercooler air outlet,which is towards the front left of the engine bay

The road speed for all the measurements was 80 km/h and the radiator and intercooler fans were not operating when the measurements were taken.(Interestingly,the underbonnet pressure measurably rises when the rad fans are working –they're pushing more air into the space,you see.)

The first measurements were taken with the standard undertray configuration, as shown in the pic above. As the table below shows, the pressure build-up in the engine bay at 80 km/h was 0.4 inches of water.

	Standard Undertrays
Rear of bonnet	0.4 inches
Near intercooler	0.4 inches



The short factory undertrays were then removed, leaving an opening that allowed the road to be seen by peering down between the radiator and the engine. The table below shows the measurements that were taken. As can be seen, the pressure at the rear of the engine bay stayed the same at 0.4 inches but the pressure at the front of the engine bay (which is where the intercooler is mounted) rose to 0.5 inches of water. This explained why the rad and 'cooler didn't work as well with the small undertrays removed.

	Standard Undertrays	No Undertrays
Rear of bonnet	0.4 inches	0.4
Near intercooler	0.4 inches	0.5



A test undertray was then fabricated from some plastic sheet that had once backed an advertising hoarding. The front of the trial undertray was held in place with cable ties connecting to the lower edge of the bumper and at the rear, by a wire that connected it to the anti-roll bar. The undertray was allowed to droop down at the rear, creating a gap that reached about 10cm in the middle.

This photo shows the test undertray in place.

the pressure in the front part of the engine bay by 40 per cent. Significantly, it was also much better than the standard undertrays, reducing the pressure build-up over them by 25 per cent.

The measurements taken with this undertray are shown in the table below. As can be seen, the pressures found towards the front of the engine bay are markedly altered by the presence and shape of the front undertray. Over having no undertray at all, the trial plastic undertray reduced

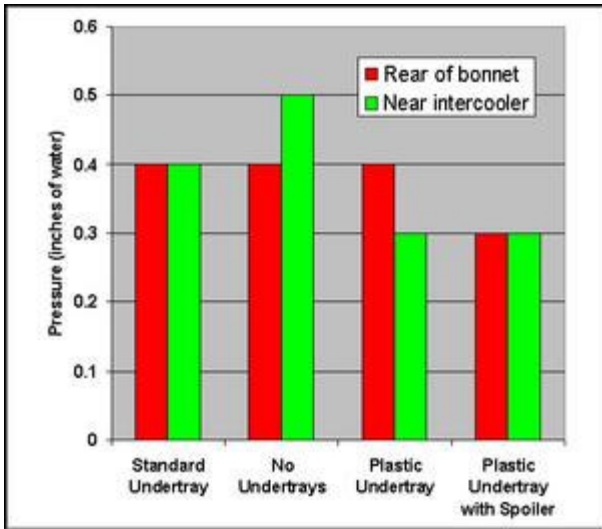


	Standard Undertray	No Undertrays	Plastic Undertray
Rear of bonnet	0.4 inches	0.4	0.4
Near intercooler	0.4 inches	0.5	0.3

Next a spoiler lip was added to the undertray. The trial lip was formed from foam rubber and was 5 x 5cm, being attached to the undertray 15cm back from the leading edge.

The measured results are shown in the table and graph below. Over the new undertray alone, the lip made no difference to the recorded pressure at the front of the engine bay but had a dramatic effect on the rear pressure –dropping it by 25 per cent.

	Standard Undertray	No Undertrays	Plastic Undertray	Plastic Undertray with Spoiler
Rear of bonnet	0.4 inches	0.4	0.4	0.3
Near intercooler	0.4 inches	0.5	0.3	0.3



So compared with standard, the new trial undertray and spoiler lip decreased the front and rear pressure engine bay build-ups by 25 per cent. Over having no undertray at all, the new combo dropped the front and rear underbonnet pressures by 25 per cent and 40 per cent, respectively. This major pressure drop (improving airflow through all the front-mounted heat exchangers) is especially important to consider if your car has no undertray.

Why They Worked –Maybe!

Measuring that in fact these trial designs **did** work is far better than any theory –but what is likely to have been going on?

Firstly, the absence of any undertrays probably created turbulence under the engine bay. Despite turbulence often being characterised as ‘low pressure’ it can have the effect of preventing other airflows smoothly joining it. By having a relatively smooth undertray hanging down at the rear, air is accelerated between the undertray and the road, better drawing air out of the engine bay at the trailing rear edge of the undertray.

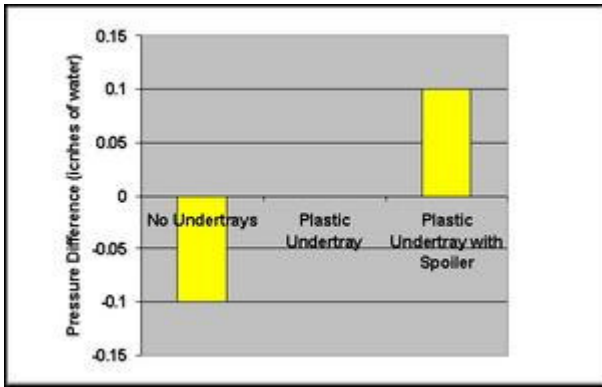
And the spoiler? Like nearly everything in car aerodynamics, this partly contradicts what was just said –the spoiler is likely to have created a slightly lower pressure behind it, either by changing the effective shape of the undertray or by causing localised high speed turbulence.

Intercooler Measurements

The measurements taken so far were referenced against cabin pressure –with the windows open, effectively the same as ambient. However, because I wanted to achieve a specific outcome (better airflow through the radiator and **especially** the intercooler) I decided to do some more measurements. These were to be true differential measurements –that is, carried out by running two sensing tubes from the measuring instrument to either side of the intercooler and then measuring the actual pressure difference across the core.

And what an eye-opener these measurements were! Remember, the higher the pressure difference across the intercooler, the more air that will be flowing through it.

	No Undertrays	New Plastic Undertray	New Plastic Undertray with Spoiler
Intercooler Pressure Differential	Minus 0.1 inches	0	0.1 inches



core would have been occurring.

The table above and this graph show that without any undertrays in place, the air from under the bonnet is likely to have been flowing **out** through the bonnet scoop! That is, there was a measured higher pressure under the intercooler than on top, even at 80 km/h! No bloody wonder intake air temps went up in this configuration – the air was coming in through the radiator, being heated, then passing through the intercooler and out the forward-facing bonnet scoop!

I had had a **pre-heater** happening not an intercooler...

With my mock-up plastic undertray in place, the pressure at 80 km/h was the same top and bottom of the intercooler. That is, no airflow through the

And with the trial plastic undertray and the foam rubber spoiler, I had a very small positive differential of 0.1 inches – the pressure was a little higher on top than underneath.

Hmmmmmm.

This was serious food for thought. When the intercooler fan is off, the flow through the intercooler core is lousy – sometimes backwards, even.

I then made a cardboard undertray that I fitted under the intercooler side of the engine bay. I replicated the foam rubber spoiler with more cardboard, then went for a drive. The resulting pressure differential was zero... **unless I was in the turbulent wake of another car**, where it was 0.1 inches! Yes, incredible as it sounds, the intercooler airflow was clearly being affected by other vehicles – in this case, when following another vehicle, it got better.

This was all getting seriously involved, so rather than spend more time on mock-ups, I decided to start work on the real thing.

Prototyping...

By far the easiest way of assessing aero changes is to make quick and easy mock-ups of proposed undertray shapes out of cardboard and/or sheet plastic, cable ties and sticky tape. It might attract some interested looks from passers-by, but in five minutes of on-road pressure testing you can prove or disprove a design.

Not mentioned in the main text is another front-end shape that was trialled – a straight up/down spoiler so low that it scraped on the ground. Despite preventing lots of airflow under the car, the pressure differential across the intercooler remained at zero. So this quickly showed that there was no point in going for a deep front spoiler – it didn't work.

Incidentally, that goes against nearly all the textbook wisdom...

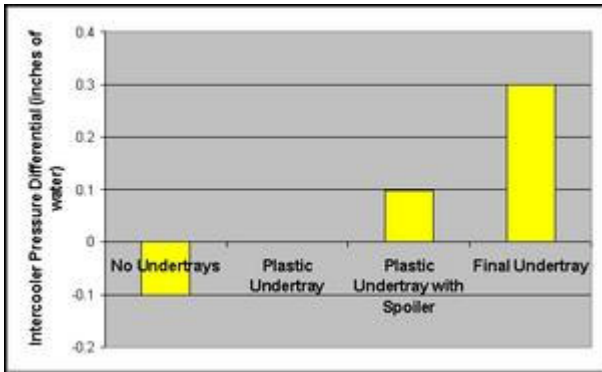
The New Undertray

Undertrays of this sort can be made from a variety of materials, including fibreglass, ABS plastic, polycarbonate (Lexan) or marine plywood. I chose ABS – a tough plastic that can be bent when heated and is easily drilled, sanded and cut. I bought a half-sheet offcut from a plastics shop for AUD\$28. (To find outlets selling a variety of types of plastic sheet, look up 'plastics' in the Yellow Pages.)



I won't take you through every design iteration made with the ABS, but after hours of constructing and testing, constructing and testing, I struck gold. With the short undertray configured as shown here (flush with the lower bumper at the front, angled slightly downwards and open at the rear, and with the sides sealed-off with angled folded panels), the measured pressure differential across the intercooler skyrocketed to 0.3 inches of water at 80 km/h.

	No Undertrays	Plastic Undertray	Plastic Undertray with Spoiler	Final Undertray
Intercooler Pressure Differential	Minus 0.1 inches	0	0.1 inches	0.3 inches



In the above table and on this graph you can see what an incredible change that is –no less than a 400 per cent improvement over having no undertray at all! Over the worst-case scenario (ie no undertrays) the intake cruise air temp on a 30 degree C day also dropped from 65 to 47 degrees C.... Yes, the intercooler was now working –even without the fan on!

So could the pressure difference be improved even further with the addition of a spoiler? The answer was ‘no’. Despite trialling lip spoilers in different positions and of different heights on the undertray, no significant gain in pressure across the intercooler could be made with this version of the undertray.

And what about underbonnet pressures –the starting point of the measuring process?

	Standard Undertrays	New Undertray
Rear of bonnet	0.4 inches	0.4 inches
Near intercooler	0.4	0.1 inches

Towards the front of the engine bay the underbonnet pressure has been reduced by 75 per cent, from 0.4 inches down to 0.1 inches (both at 80 km/h). However, the final version of the undertray does not reduce pressures towards the rear of the engine bay at all. To a large extent, getting a big pressure decrease at the front of the engine bay is far more important on this car than at the rear –the intercooler and radiator are both mounted near the front of the car and so have their exit air exhausting at this position. (Of course, a car with a top-mount intercooler mounted over-or behind-the engine may be a completely different kettle of fish!)

Conclusion



This series is entitled ‘Undertrays, Spoilers & Bonnet Vents’ but there isn’t going to be a front spoiler. As indicated above, several versions were trialled but they were not effective at increasing the pressure difference across the intercooler, while at the same time they reduced ground clearance.

However, the simple undertray (well, simple now that all the work has been done!) makes a radical difference to the airflow passing through the intercooler –an increase in airflow that measurably drops cruise intake air temps.

(If the car didn’t run an intercooler fan which comes on at low road speeds and also when intercooler temps are high, the new undertray would also have dropped peak intake air temps considerably.)

In addition, it is noticeable that the radiator fans (being monitored by a LED inside the cabin) don’t operate nearly as often as previously –basically, if the car is moving on the flat, the fans stay off, whatever the outside temp. IOTW, the radiator is now working much better.

Playing with different undertrays and front spoilers can result in significantly increased intercooler (and radiator) efficiencies. However, if you’re not measuring actual aerodynamic pressures, you’re working in the dark –even apparently minor changes in design can yield major changes in aerodynamic flows.

Next week –fitting the bonnet vents

Undertrays,Spoiler & Bonnet Vents,Part 3

Last week in [Undertrays,Spoiler & Bonnet Vents,Part 2](#) we showed you how a newly-fitted undertray dropped the underbonnet pressure build-up on our guinea pig Maxima V6 turbo by 75 per cent at 80 km/h,considerably improving flow through the intercooler and radiator.But the pesky under-bonnet pressure build-up still occurred and got even higher when the car was driven faster.

Time for some bonnet vents...

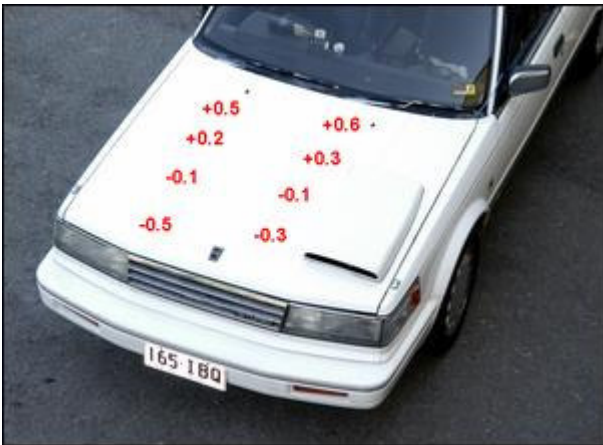
Siting Bonnet Vents



DaimlerChrysler graphic shows the typical frontal pressure distribution of a car.Looking just at the bonnet you can see that there is low pressure(blue)where the air wraps around the leading edge of the bonnet,grading to high pressure(green)as the air reaches the obstruction which is the windscreen.

So you wouldn't site a bonnet outlet vent close to the windscreen –in fact that's usually where the cabin ventilation inlet ducts are...they're taking advantage of that high pressure! Looking at just the exterior pressures,what we want at the vent location is the very lowest external pressure.

That's the theory –but what about on the road? By using the Magnehelic gauge(see the previous parts in this series for more on these gauges),it's dead-easy to directly measure the pressures over the outside of the bonnet.Simple run a tube from the Magnehelic gauge to the area to be measured,making sure that the open end of the tube is at right-angles to the direction of airflow.Leave the other port of the gauge open,and swap the tube from port to port,depending on whether you find that you're measuring a high or low pressure.



This is exactly what we did on the Maxima,using the same 80 km/h road speed for all testing.The results were astounding –not because they reflected the textbook example shown in the graphic above,but because the pressure variations were so great! As can be seen here,the front half of the bonnet surface was clearly a negative pressure zone,while the rear half was all in positive pressure.And the further forwards the measurements were taken,the lower the pressure;and the further backwards,the higher the pressures!

In Part 2 of this series we measured the maximum underbonnet pressure at 80 km/h as 0.4 inches of water –and here,near to the windscreen,the surface pressure was 0.6 inches! IOTW,place a bonnet vent at this location and air will be flowing in from outside-ie through the vent and into the engine bay! So much for relieving the pressure under the bonnet...

Clearly,the further forward that the vents were to be placed,the lower the available outside pressures.

But the outside pressures are literally only half the story.What about the underbonnet pressures? As mentioned above,with the new-design undertray in place,the maximum pressures under the bonnet(again at 80 km/h)was 0.4 inches.This was recorded across the rear half of the engine bay.At the front of the engine bay(in reality,about 30cm back from the radiator),the underbonnet pressure was 0.1 inches.

So what were the alternatives?

<O😊> </O😊>	Leading Edge of Bonnet	Front Third of Bonnet	Midpoint of Bonnet	Rear of Bonnet
Above bonnet pressure	-0.5	-0.3	0.1	+0.6
Below bonnet pressure	0.1	0.1	0.3	0.4
Difference	0.6	0.4	0.2	-0.2

As the table above shows, the greatest difference between the underbonnet and overbonnet pressures is at the very leading edge of the bonnet, where it is 0.6 inches of water. (However, it's very hard to site a vent here and moving backwards a little to the front third of the bonnet still gives 0.4 inches of water pressure difference.)

Types of Vents



For reasons of aerodynamic drag (which we've not touched on at all in this series), it is normal to direct the air out of vents as parallel to the surface as possible. This causes least turbulence. But of course bonnet vent selection also depends on issues like price, durability and aesthetics – bonnet vents are much more visible than undertrays! Taking into account all of these factors, I purchased from a boating supplies shop (Whitworth's Nautical World) some stainless steel louvred vents. These were 325 x 111mm and cost AUD\$19.50 each.

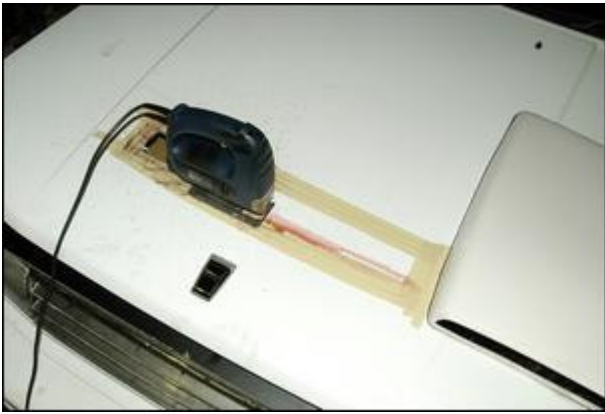
The vents were bought prior to making the above pressure measurements (silly boy!) and I had figured they would be installed north-south, i.e. with their long axis parallel with the car. However, after making the pressure measurements, I realised that this would put a considerable portion of each vent in a less than ideal area of pressure – it would be like each vent was only half as big as it really was...

I then reconsidered. What was really required was a vent that could be mounted east-west, i.e. across the bonnet. This would be best sited as far forward as possible: realistically, about where -0.3 surface pressure existed. In fact, the shape of the vent wouldn't be all that different to a ventilation inlet grille at the base of the windscreen – except it would be sited a long way forward and exiting (rather than entrancing) air.



A trip to the wreckers and a long walk around the yard found the ideal vents – the ventilation inlet vents on a Holden VL Commodore, which are normally positioned in the trailing edge of the bonnet. The cost was AUD\$10 for the pair.

Vent Installation



The Commodore vents come in two pieces. If required –as was the case here –they can be shortened by chopping off a section at each end. (The vent assembly is slightly curved in plan, so this keeps their symmetry.) A hacksaw was used to do this then an electric jigsaw was used to cut out the long, mostly rectangular hole in which they sat. Some metal clips (made from ‘eye’ electrical terminals) and double-sided tape were used to hold them in place.

Measurements

As we’ve covered, there are two ways of assessing the effectiveness of the new vent:

- 1) measure underbonnet pressure
- 2) measure the pressure difference across the intercooler (or radiator, etc)

In this case the underbonnet pressure itself didn’t concern me **allthat** much –I wanted as much airflow through the intercooler as possible and that would depend on the pressures each side of the ‘cooler’!

However, underbonnet pressures were measured first.

	New Undertray	Bonnet Vent
Rear of bonnet	0.4 inches	0.3 inches
Near intercooler	0.1 inches	0.1 inches

As the table above shows, the underbonnet pressure with the vent in place was unchanged near to the intercooler and down by 25 per cent further rearwards in the engine bay. However, the figure for near the intercooler is a little deceptive, as measuring of the pressure differential showed:

	Final Undertray	Bonnet vent
Intercooler Pressure Differential	0.3	0.4 inches

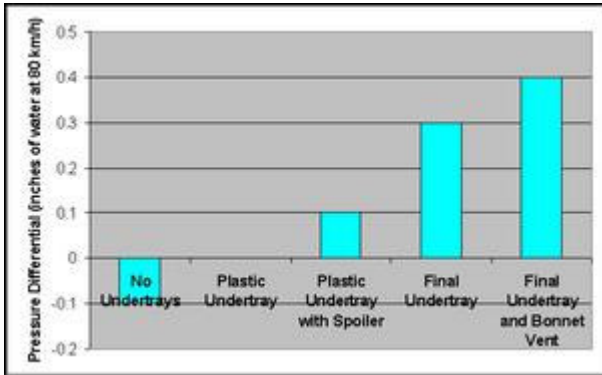
Yes, as can be seen in the above table, the measured pressure differential across the intercooler at 80 km/h averaged 0.4 inches –up from 0.3 without the bonnet vent. But if the underbonnet pressure was unchanged, where did the extra difference come from? The answer is in the ‘average’ prefix –the new difference ‘averaged’ 0.4 inches.

Prior to the bonnet vent being installed, the pressure differential across the intercooler was fairly stable at 0.3 inches of water. But with the bonnet vents installed, even the slightest gust of wind caused the pressure differential to leap. Driving through some hilly urban areas on what was apparently a calm day, tiny gusts of wind took the pressure difference as high as 0.6 inches! This lifted my subjective ‘average’ figure from 0.3 to 0.4 inches of water.

This effect could also be observed at higher speeds –the pressure differential increased considerably as the car went faster, whereas before the bonnet vent was installed, the pressure difference across the intercooler had remained pretty well constant.

Final Tally

Concentrating on the pressure difference across the under bonnet intercooler, what do the final figures look like? (This is the scorecard of the entire three part series!)



Over having no under tray at all, the fitting of the new under tray and bonnet vent have lifted the pressure difference across the intercooler from minus 0.1 to plus 0.4 inches of water. Or to put it another way, the pressure difference across the intercooler has been increased by a factor of five! You can't therefore say that there's now five times as much external airflow through the intercooler at 80 km/h, but you can be sure that it has risen considerably. The measured intake air temp certainly shows that the intercooler is now working far better.

Conclusion

In this series we've given you a heap of figures –perhaps too many. But in the area of DIY aerodynamic modification, there is always a lot of talk, very little action –and never any data! We hope that we've helped address that problem –and remember, all you need is a cheap Magnehelic gauge and you can collect figures for your own car.

Let's summarise what we've found:

- Scoops, vents and air exits do not always work as you intuitively figure they do
- It's easy and cheap to collect information that allows you to make intelligent aero design decisions
- Trial design front undertrays can be easily made from cardboard, plastic sheet, etc and then road tested
- A well-designed undertray can make a radical difference to the airflow through intercoolers, radiators, oil coolers and air-conditioning condensers
- Bonnet vents should only be sited after making under- and over-bonnet pressure measurements
- Properly sited bonnet vents can further improve airflow through intercoolers, radiators, oil cooler and air-conditioning condensers

The bottom line: the Maxima now boasts far improved intercooler efficiencies and noticeably improved radiator performance from two aerodynamic mods that together cost AUD\$38.

Oh yes, and a few days of DIY work....