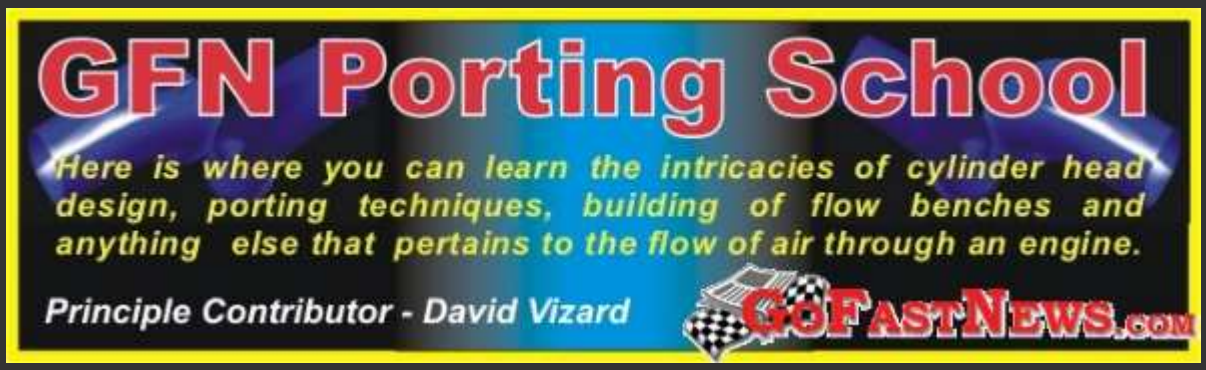
07-01-2008, 09:23 AM #1 (permalink)

DavidVizard-GFN OFF
Pit Crew

Join Date: Apr 2007
Posts: 840

Porting School #5 Identifying Primary Restrictions



#5 Port Appraisal

The first step toward more flow is identifying a flow restriction.

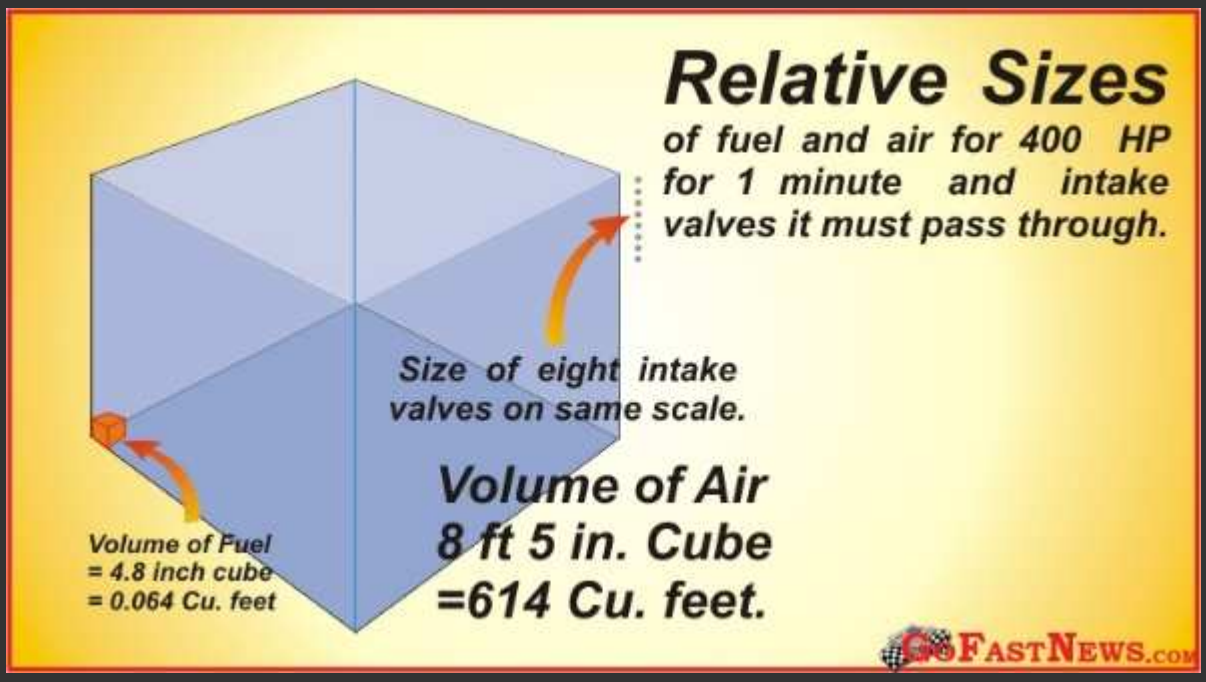
By

David Vizard

The small block Chevy head with it's pushrod pinch point just in from the manifold face probably brings about more initial porting misconceptions than any other head. A novice looking at such a head almost immediately assumes that the pinch point must be the restriction stopping the engine from making much bigger hp numbers. The reality is far different and it sometimes takes a graphic example to convince a would-be porter otherwise.

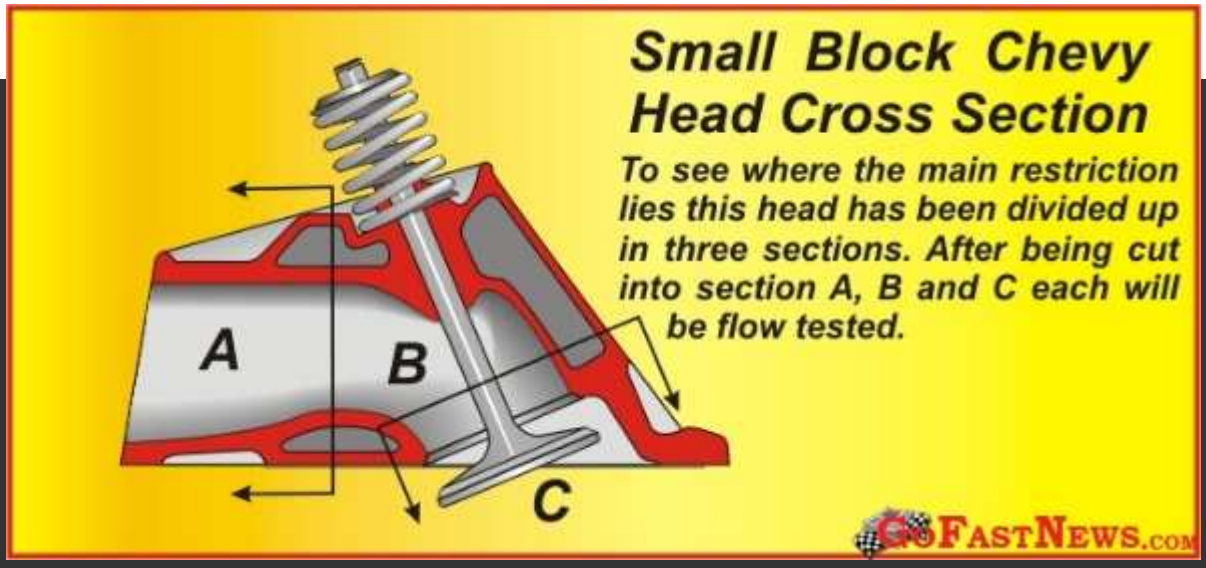
Granted there are a lot of aspects than we need to cover if the intent is to develop an optimal port for

what ever performance application you have in mind. And before any of you over enthusiastic novice porters start bombarding me with questions on what will be down the road topics let me tell you - **we will get there**. But we have to start somewhere so let us begin by considering the magnitude of the task at hand – namely filling cylinders with an air fuel mixture up to high rpm. The following drawing should put things into prospective. When you realize the physical proportions of the elements involved achieving our goals don't look to be quite as easy to achieve.



The real point to note here is how small the intake valves are in relation to the volume of air that has to be drawn in to make just 400 hp. That is a figure that most of us relate to nothing more than a hot street 350. If the goal is 600 hp the task of filling the cylinders is even more daunting. As much as this looks to be a great illustration of the situation involved it does in reality fall short. Let us not forget that at any one moment in time in a V8 that 5 of the 8 valves are closed so in effect all the air has to pass through just 3 valves. Things are now looking really serious but it does not stop there. We also must take into account that valves open and close and that on average they are at half lift. If we now add this into the equation we can say that for all practical purposes all that air for 400 hp has to pass through the equivalent of just one and a half of the valves shown. So what does this all tell us? What it means is if you want to make real hp from your engine you had best be a real porter and know what you are doing – because it is hardly all a walk in the park!

If you have now absorbed the implications of the above then it's time to move an and establish just where in the induction/exhaust system the real restrictions lie. In an effort to put some numbers on it I did, many years ago, saw up a small block Chevy head and flow each individual section to get a better idea of the relative flow efficiencies of various parts of a port. Although I am using a small block Chevy port here as an example what we are looking at carries over to most ports. First let's look at a typical production casting as per that shown below.



This head has the valve at about what would be half lift for a sane performance street cam. This represents the average lift seen at the valve.

Using a clay radius entry on each section (not shown in these drawings) the flow figures are seen. From these numbers it is obvious that the entry point A is not the prime restriction but the area at and around the valve seat.

From the above drawings it appears that the point of greatest flow restriction is at the valve seat. This is actually the case and applies to both the intake and exhaust. The reality of the situation is that the most important and influential part of any cylinder head port is the part ½ inch above to ½ inch below the seat itself. From this we can see that any work we do to the head should start by shaping the before and after seat area such that it flows as effectively as possible.

For the novice head porter the info just given could well save a lot of wasted time. Before even considering enlarging the pinch point area of the port (or any part of the main section of the port on any head for that matter) you should come to terms with the seat and bowl area. Reworking this is often termed 'pocket porting' but it can mean different things to different folk. Here, for every-ones benefit, is the GFN definition of pocket porting. It essentially implies the blending of the valve seat into the bowl area in a smooth and well rounded manner. In our case it also means tidying up the short side radius of the port so as to make the best of that. If you are doing a pocket port job then it also implies that the intake and exhaust valves have a blending form applied to them on the back face, and in the case of the exhaust, a radius on the front face. This plus a little chamber work pretty much constitutes a pocket port job. As to how effective it can be we have to consider what it was we started with. If it was a stock Ford or Chevy head prior to about 1990 the improvements can be quite substantial. **In fact a pocket porting job well done can find about 2/3 of the extra air available from a basic full porting job but for about 1/3 of the expenditure in time and effort.** This makes a pocket porting exercise a very effort effective deal. For later style heads such as the Chevy Vortec heads there is less to be gained from the intake although the exhaust responds well. These later heads are manufactured using a far more refined casting technique and, as a result, the factory leaves less on the table for the porter to find.

In Porting School #6 we will continue our journey through the inlet flow processs in more detail and reveal some little known methods of identifying and minimizeing valve shrouding.

David Vizard

Other parts in this series are at:

#1 Porting School #1 - Why engines need airflow

#2 Porting School #2 - Super Cheap Flow Bench

#3 Porting School #3 Budget Bench Calibration

#4 Porting School #4 - Budget Bench Electronics

#5 Porting School #5 Identifying Primary Restrictions

#6 Porting School #6 - Secrets to reduce valve shrouding

#7 Porting School #7 - Power & Port Volumes

#8 Porting School #8 Optimal Port area's

#9 Porting School #9 - 5 Rules to Goof-Proof Porting!

#10 Porting School #10 - Pushrod Pinch Point Power Issues

In addition to the Porting School articles there are directly related cylinder head development subjects at the following locations:

Wet Flow

Six Wet Flow Mistakes

Combustion Dynamics Series

#1:- Turbulence and Combustion Dynamics

#2:- In cylinder Turbulance and Combustion Dynamics

#3:- Turbulance and Combustion Dynamics - Part 3

#4:- Coming soon

#5:- Turbulance and Combustion Dynamics - Crevice Volumes - Stealth Power Thief

Want to learn how to develop and port heads for high performance professionally?
If so click on the link below.

Last edited by DavidVizard-GFN; 09-18-2008 at 09:20 PM.

07-03-2008, 03:50 PM #2 (permalink)

FlowSpecialist OFF
Tire Changer

Join Date: May 2008
Posts: 129

Quote:

> Originally Posted by **DavidVizard-GFN**
> *If it was a stock Ford or Chevy head prior to about 1990 the improvements can be quite substantial.* ***In fact a pocket porting job well done can find about 2/3 of the extra air available from a basic full porting job but for about 1/3 of the expenditure in time and effort.*** *This makes a pocket porting exercise a very effort effective deal.*

Let's put a few numbers in to reinforce what Dave says about the importance of the valve, seat and areas immediately adjacent. Back in the mid 90s I was heavily involved in a race series in the UK for Ford Fiestas using the 1600 CVH engine. The rules didn't allow any porting at all so an even more restrictive situation than the 'pocket porting' DV refers to above. Seats could be recut although the throat size couldn't be altered and for a while at least they allowed valves to be backcut at 30 degrees so that the seat width on the valve matched that in the head. The chamber being a hemispherical one imposed no shrouding so that also wasn't an issue or a place that gains could be found. In essence every extra horsepower had to come from valve and seat work and I usually raised the bhp of my engines compared to the competition by 10% just from this area alone. That was enough to easily win the series every year I built engines for it.

Much R&D went into finding the optimum valve and seat shape profile for the engine.

The flow figures below at 25" of water show figures for 1) the standard head, 2) just the valve backcut, 3) The seat recut and blended into the chamber, 4) a fully ported head for a different race series. Inlet valve is 42mm.

LIFT.....STD....VALVE....SEAT.....FULL MOD
50.....23.8.....25.0.....27.5.....25.2
100.....48.3.....48.9.....52.8.....53.3
150.....66.2.....75.5.....81.3.....77.5
200.....86.9.....101.6....110.5.....106.7
250....109.6....125.9....134.2.....132.8
300....129.5....142.9....149.1.....152.5
350....141.9....150.2....152.9.....163.4
400....145.4....150.9....153.6.....171.2
450....146.6....150.9....154.5.....178.0
500....147.5....151.0....155.5.....183.3

Power.100%..106.3%..110.5%...119.8%

The power potential figures are from an algorithm of my own devising which was found to give good correlation to dyno results on this engine.

Note how important just the valve shape is. A 30 degree backcut to reduce the seat on the valve from about 3.5mm wide down to 2mm to match the seat in the head and blend nicely into the back of the valve has raised mid lift flow by a massive 17% at 200 thou lift and strong gains all the way from 150 thou to 350 thou. The net power potential increase from just this mod is 6.3%. With the seat cut this rises to 10.5%.

Note also how most of the benefit from both valve and seat work is in the low and mid lift flow region. Peak flow (the cam in this series only lifts to 400 thou) has gone up much less than the overall power percentage increase. Another reason why trying to predict power figures from just the peak lift flow as per the Superflow manual is a waste of time. Low and mid lift flow is crucial to power output.

The fully modified head sacrificed some low lift flow to get better high lift flow and better suit higher lifting cams. Flow doesn't start to show an improvement until 300 thou lift. This is a very common result as you push the boundaries of what the standard port shape can cope with. It also shows that just the valve and seat profile control the flow almost totally at low to low/mid lift. Power potential has gone up

to 19.8%. Flow continued to increase into the 190 CFM range at 600 thou and over although most cams don't lift anywhere near that high.

So in this case the valve and seat work alone is worth just over half of what a complete top notch porting job can achieve. This percentage will vary considerably with type of head but that's not an uncommon result, especially on older type cylinder heads.

What I must also stress is the importance of the exact seat profile. Many people take their heads into a shop and ask for "three angle valve seats please" thinking that's a homogenous commodity you can buy like a bag of sugar. What you get back can actually vary enormously in terms of seat width, top cut angle and bottom cut angle. Often there will little or no improvement over standard. It might even be worse. If you don't know exactly what to ask for then don't be surprised if the guy cutting your seats has no idea either.

Dave

Last edited by FlowSpecialist; 07-03-2008 at 04:42 PM.

QUOTE

07-06-2008, 06:28 PM #3 (permalink)

Rick360 OFF
Garage Sweeper

Join Date: Sep 2007
Location: Missouri
Posts: 19

Quote:

> Originally Posted by **DavidVizard-GFN**
> *it appears that the point of greatest flow restriction is at the valve seat. This is actually the case*

I've done some flow testing where I **removed the valve and the flow did not increase**. Usually this was on heads that had a fairly small (relative to valve throat) pushrod pinch. I bet the section of just the valve and seat would flow very good with the valve opened more. Most flow enters the cylinder when the valve is much more than 1/2 lift when the piston is moving fastest, why use such a low lift. Flow at low lifts may be important on street engines or restricted cam engines, but flow at low lift is a detriment in a serious racing engine IMO.

I agree that the valve seat is an important part of the port as is the short turn, but this test means very little at such a low lift. I think it is quite obvious the valve is the restriction when the valve is partly open. The valve would have to be open to ~ .23 L/d (~.480" on a 2.05 valve) to have the actual valve curtain area larger than the valve throat at 90%.

Rick

QUOTE

07-06-2008, 08:28 PM #4 (permalink)

FlowSpecialist OFF
Tire Changer

Join Date: May 2008
Posts: 129

Quote:

> Originally Posted by **Rick360**
> *I've done some flow testing where I **removed the valve and the flow did not increase**. Usually this was on heads that had a fairly small (relative to valve throat) pushrod pinch. I bet the section of just the valve and seat would flow very good with the valve opened more. Most flow enters the cylinder when the valve is much more than 1/2 lift when the piston is moving fastest, why use such a low lift. Flow at low lifts may be important on street engines or restricted cam engines, but flow at low lift is a detriment in a serious racing engine IMO.*
>
> *I agree that the valve seat is an important part of the port as is the short turn, but this test means very little at such a low lift. I think it is quite obvious the valve is the restriction when*

> *the valve is partly open. The valve would have to be open to ~ .23 L/d (~.480" on a 2.05 valve) to have the actual valve curtain area larger than the valve throat at 90%.*
>
> *Rick*

Perhaps another way of expressing the point that DV is making is that many novice head porters, and these are after all 'basics' articles, start by attacking the easy to reach bits of the port which do very little for flow until the important areas have been properly modified.

Dave

QUOTE

07-07-2008, 06:12 PM #5 (permalink)

Lasse OFF
Garage Sweeper

Join Date: May 2008
Location: Finland
Posts: 84

I made some modifications to intake port of old SBC dart 2 heads. I did get much improvent in flow numbers, but at certain point of modifications the sound of flow went very pulsating. I drilled pushrodhole bigger, loctited metal sleeve in and grinded "bump" of pushrodhole at intake port so sleeve came to visible. Then I smoothed grinding. The sound went back to very smooth, it wasn't pulsating anymore. Flow did get only small improvent at high lift (where pulsating sound occured), but I think if I had continued porting, this would been a limiting area. I must continue that project someday, when I have time for it.

I don't mean area of intake manifold face is too small (actually, I think it is too big.), but a "bump" of pushrodhole of dart 2 is very big. So was it creating some vortex or something?

QUOTE

07-07-2008, 06:32 PM #6 (permalink)

FlowSpecialist OFF
Tire Changer

Join Date: May 2008
Posts: 129

Pulsating flow usually means the flow is breaking away from the port wall somewhere. The short side bend is the likely culprit. I doubt if the straight part of the port had anything to do with it. You may have changed the flow pattern further down though.

Knife edged dividers between the two runners in 4v heads also often make a strange noise. I prefer to shape them with a rounded form as in classical teardrop shaped streamlined cars or planes. Knife edges are shapes you associate more with supersonic flow. I see no need for them in cylinder heads.

Dave

QUOTE

07-07-2008, 06:44 PM #7 (permalink)

FlowSpecialist OFF
Tire Changer

Join Date: May 2008
Posts: 129

> Quote:
>
> Originally Posted by **Rick360**
> *flow at low lift is a detriment in a serious racing engine IMO.*
> *Rick*

I missed this little nugget first time round. It's a view I've seen from time to time in various places. If you want to expand on your reasons why you think it is true I'll get back to you.

Dave

07-07-2008, 07:29 PM #8 (permalink)

Lasse OFF
Garage Sweeper

Join Date: May 2008
Location: Finland
Posts: 84

Quote:

> Originally Posted by **FlowSpecialist**
> *Pulsating flow usually means the flow is breaking away from the port wall somewhere. The short side bend is the likely culprit. I doubt if the straight part of the port had anything to do with it. You may have changed the flow pattern further down though.*

I have older experience of pulsating flow with Ford Pinto 2000cc head and reason was short side turn, indeed. I agree your words makes sense. If flow is breaking away from port wall, it is reasonable that it will turn to continous pulsating motion. When flow breaks away from wall, pressure gets very low near wall and again flow turns near wall and etc. Does this sound right?

Quote:

> Originally Posted by **FlowSpecialist**
> *Knife edged dividers between the two runners in 4v heads also often make a strange noise. I prefer to shape them with a rounded form as in classical teardrop shaped streamlined cars or planes. Knife edges are shapes you associate more with supersonic flow. I see no need for them in cylinder heads.*
>
> *Dave*

I had allways wondered if knife-edging have any benefits over teardrop shape... Still, I have seen so many knife-edged guide bosses and 4v-dividers, that it made me to hesitate. Nice to hear I wasn't wrong. Again my theory is for knife-edging that flow change sides over knife-edged obstruction. That will also be explanation if flow is pulsating.

07-07-2008, 09:54 PM #9 (permalink)

Rick360 OFF
Garage Sweeper

Join Date: Sep 2007
Location: Missouri
Posts: 19

Quote:

> Originally Posted by **FlowSpecialist**
>
> Quote:
>
> > Originally Posted by **Rick360**
> > *flow at low lift is a detriment in a serious racing engine IMO.*
>
> *I missed this little nugget first time round. It's a view I've seen from time to time in various places. If you want to expand on your reasons why you think it is true I'll get back to you.*
>
> *Dave*

There are a couple reasons.

1. Better forward flow usually means better reverse flow (exhaust back into intake). During overlap any benefit from tuned exhaust "helping" the intake is in a very narrow rpm band (if it helps at all), so it is better to reduce flow in this low lift range and keep the exhaust out of the intake at all other rpms than

to try to help the intake at some narrow range. I'll get back to my beliefs of overlap later.

2. If the intake port keeps up perfectly with the piston we can never get much over 100% VE (depending on compression) because the inertia effect after BDC would be gone. If cylinder filling is always slightly behind actual piston demand, you maintain port velocity late in the cycle giving much better inertia at a time it can be used, after BDC. If you limit flow too much you will increase pumping losses and hurt power even with more VE%.

Gaining low lift flow has the same effect as adding intake duration. I think **one** of the reasons the steeper valve/seat angles (50º,52º,55º or higher?) helps is they keep the valve curtain area pinched off more at low lifts. This reduces reversion flow during overlap as well as low lift flow.

Back to my beliefs on overlap and the exhaust "helping" the intake get started moving. In one of my engine books (I think it was "Scientific Design of Int & Ex Systems), they did some pressure testing of cylinder filling that indicated that even if intake flow was late starting, it made it back to about the same point (cyl press) late in the cycle and was on a steeper rise, filling the cylinder better ABDC. The overlap period should be used to purge the chamber of exhaust and no matter how low the exhaust pressure pulse is, the only way to completely rid the chamber of exhaust is with a "vent" somewhere else in the chamber to let something into the chamber. The intake port can be used to vent the chamber and a low pressure on the exhaust can then pull intake charge thru the chamber and if a little goes out too, its better than some exhaust leftover. No need for any "helping" of the intake flow in the beginning, just allow enough flow to vent the chamber out the exhaust.

That's all I have time for now.

Rick

QUOTE

07-10-2008, 10:23 PM #**10** (**permalink**)

DavidVizard-GFN OFF
Pit Crew

Join Date: Apr 2007
Posts: 840

Quote:

> Originally Posted by **Rick360**
> *I've done some flow testing where I **removed the valve and the flow did not increase**. Usually this was on heads that had a fairly small (relative to valve throat) pushrod pinch. I bet the section of just the valve and seat would flow very good with the valve opened more. Most flow enters the cylinder when the valve is much more than 1/2 lift when the piston is moving fastest, why use such a low lift. Flow at low lifts may be important on street engines or restricted cam engines, but flow at low lift is a detriment in a serious racing engine IMO.*
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> *I agree that the valve seat is an important part of the port as is the short turn, but this test means very little at such a low lift. I think it is quite obvious the valve is the restriction when the valve is partly open. The valve would have to be open to ~ .23 L/d (~.480" on a 2.05 valve) to have the actual valve curtain area larger than the valve throat at 90%.*
>
> *Rick*

Rick,

You obviously reading word for word what is being said here and throwing in liberal doses fo your own experience - great stuff. The subject material you are speaking of is going to be covered in the near future in this series so whatch this space - and see in detail what you are taliking of in terms of valve to port geometry, sizing, shrouding etc.

There is one point thought that I would dearly like some input from you on if you have it. You mention the supposed effect that low lift flow can have on hp. I have been trying to get other people to show their dyno tests indicating that too much low lift flow for a race engine costs power. Do you know of

any good back to back tests conclusivly proving this?
DV

Last edited by DavidVizard-GFN; 07-10-2008 at 10:27 PM.

QUOTE

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