**The Elite Engine Systems Philosophy for Porsche Racing Engines**

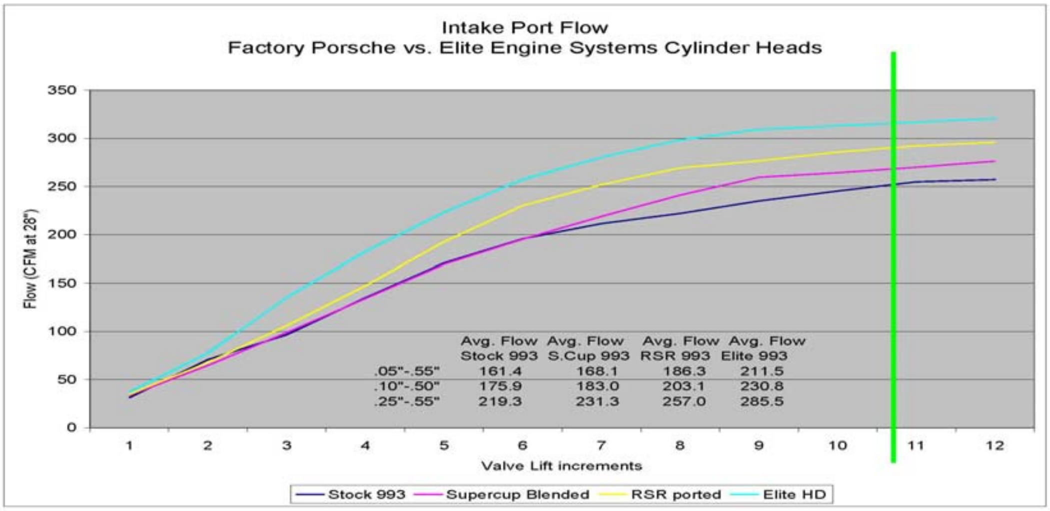
Elite's mission is to design superior Porsche racing engines with volumetric efficiencies that approach 130% at peak torque. The cylinder head design (more specifically the intake and exhaust port geometry) allows for this capability. Cylinder heads are the gate keepers for engine breathing ability and are the ultimate power capability of the engine. (A more simplified explanation than the one below is offered to the non-engineer at the end of this section).

The EESL intake and exhaust ports have been developed using a combination of science, experience, common sense and luck (yes there is some luck in this game!), with data to validate the outcome. The data collected is flow on a flow bench at a pressure 28" of water column lower than atmospheric pressure (notice the absence of the term "vacuum" which is what many people use to describe a pressure difference that is lower than atmospheric pressure).

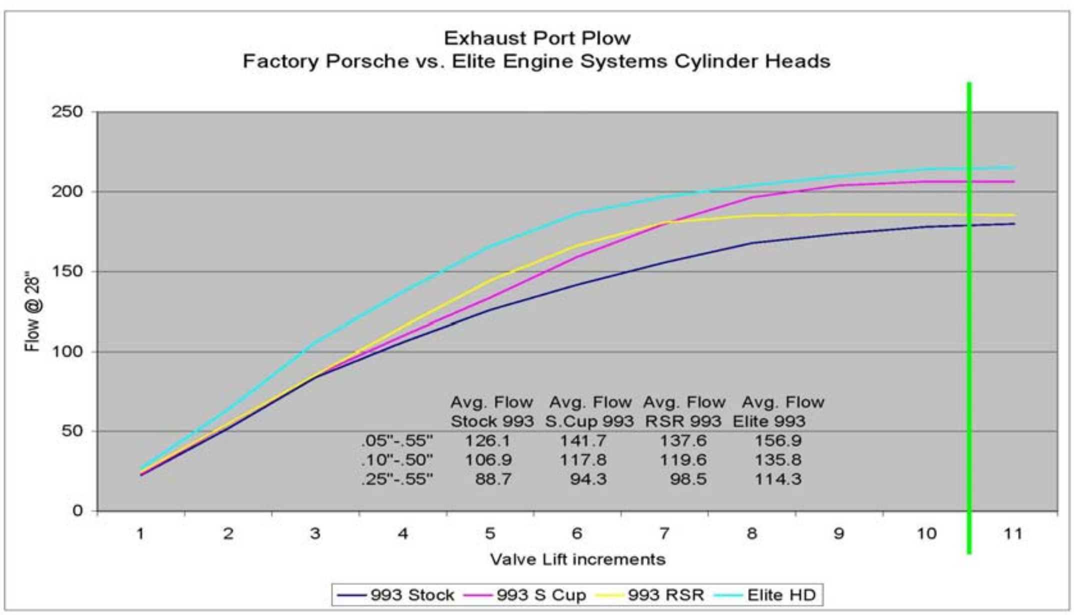
Using the intake port of the engine as an example, the receding engine piston creates a low pressure in the cylinder which is the driving force for the outside air to flow past the valve and into the cylinder where it can be 'captured' to do work for the engine. This process can be modeled with a flow bench that produces such a (lower) pressure difference and is instrumented to measure how much air is actually flowing through the port. Obviously, the flow that a certain port allows through will vary with the lift of the valve. Flow data for a port in and by itself is not the only criteria that will lead to high volumetric efficiency potential; the velocity of this flow is also very important due to the momentum created by the air column. Similarly, the physical shape of the port in the bowl is important as it will change velocity into pressure right at the head of the valve. This in turn will influence how much of the air will force itself into the engine once the piston causes an increase in pressure when coming back up the cylinder (while the intake valve is still open). So, a port that flows 300 CFM at 0.500" valve lift and has a port volume of 140 cm3 and only a converging geometry (with no throat) could be vastly inferior to a port that flows 280 CFM at the same valve lift with a converging/diverging port volume of 128 cm3. The result would be an engine that is extremely sensitive to cam timing (as the effect of momentum is very low) and one that may produce insufficient torque to allow it to accelerate to the speed required for this port to make the horsepower potential associated with the flow from the data. This engine would not have a very low BMEP and would be considered peaky at best if it even makes it to the operating range where the flow of the port can be used beneficially.

One common misconception in racing circles is that "bigger is better". Ironically there is such thing as "too big" and this can result in substantially worse outcomes than even stock configurations would offer. Taking a stock Porsche port and cleaning it up to reduce the imperfections (like sharp edges and casting mismatches) often results in a significantly superior port to an all out "ported" product that generates large flow numbers but has compromises in the geometry. It is important to note however that the maximum horsepower a port can support does depend on the curtain area of the port and this area has to be increased once the velocity of air that is flowing through it reaches about 65% of the speed of sound. Increasing the size of this curtain area will increase the volume of the port and decrease the velocity of the air. This is the criteria that governs how big is actually “best”, and this in turn is impacted by the displacement of the engine and the operating speeds it is being subjected to.

EESL ports are designed for the dynamic flow pattern into the engine (as opposed to static flow bench numbers) which results from the internal engine geometries. Short connecting rod-to-stroke ratios produce a faster piston acceleration down the stroke and create a more aggressive pressure depression to drive the flow of air across the intake ports. The question is: can the valve/port combination take advantage of this aggressive pressure depression and turn it into flow of air into the engine, or is this potential to create flow wasted? The answer is: it depends on the port flow profile as the valve is opening and the piston in accelerating downward. This is the reason why the Elite systems are engineered to work together and may work well by themselves in other geometric environments, but may never produce their ultimate potential until they are “synchronized” with the other components which create the boundary conditions of the ports. In a nut shell, a great engine builder can successfully assemble some of the best engine components and do everything right during an engine build and *still* not reach the performance outcome that an EESL system was able to reach simply because the complex details of certain components are not *working together* well enough. For Porsche engines, the factory design sets many of the boundary conditions that the engine builder will have to work with. Things like bore and stroke (to meet a displacement criteria) as well as rod length and maximum valve lift can not be easily changed. There are a number of very successful engine builders who have perfected optimizing the output of these flat 6 engines when operating within the “standard” Porsche engine design confines. If you use stock length rods and bores/strokes (i.e. 76.4mm x 102mm for a 3.8 liter RSR type race engine) then you can use valve sizes that could be as large as 53mm in the intake and 43.5mm in the exhaust and design a piston that results in 13.5:1+ compression ratio and cams that may allow you a maximum of .540” lift with whatever duration profile you want. The stock cylinder heads could be modified on the intake port to anything you want (as long as you have enough metal on the head for it), while with the exhaust, due to the ceramic liner, you are stuck with certain geometry limitations. The difference between a great engine and a very good engine could be the flow allowed by the ports throughout the valve openings.




As a good engine builder you know what components to use to get a strong engine built. The graphs above and below show how the ability of the ports alone could make the difference in performance outcome. As a good engine builder you know that the intake flow numbers closer to the maximum lift of the valve are much more relevant than the total, and you also know that the exhaust flow numbers up to about 0.350" lift of the valve are much more important than the flows at maximum valve lift.




The factory RSR's 3.8 liter engine produced about ~375HP at ~7500RPM. Using your cams and piston designs, compression ratios, exhausts, intakes etc. and the cleaned up

RSR ports could move this number into the 415HP range at ~8000 RPM for top end engine builders like you. Perhaps the most experienced engine builders could possibly apply every trick of their trade in every detail of their engine and get another 10HP to make ~425Hp at ~8000 RPM. So how do you get to 450HP and beyond??? Superior ports such as the ones from EESL heads will certainly help you towards this goal! However, 450HP at 8000 RPM represents a Break Mean Effective Pressure (BMEP) of ~200psi and a corresponding volumetric efficiency of ~110% at peak power. To get these numbers at maximum speed you would need a BMEP of about ~230psi and a volumetric efficiency of ~130% at peak torque. This is easier said than done! The high velocity EESL ports are a huge ingredient, but you would need to change the internal geometries of the engine to match the dynamic pressure gradient across the valve to the discharge coefficient of the port. You would also need to design a cam that could precisely time this as well. Even the best engine builder would need to do some heavy duty engineering to make this last amount of power a reality.

The EESL 3.8 engine systems (when installed properly) generate ~450HP.

We are sure that great engine builders can take an Elite System and make even more horsepower we do when they can apply their own and unique experiences and skill! Let us know!!!

Information for the Non-Engineer

In the simplest terms, engines are air pumps that suck in (ingest) air mixed with fuel which is then compressed and ignited to produce a rise in pressure which is subsequently converted into shaft power (by expanding this pressure through a piston attached to a crankshaft). The reason why engine size is such an important variable is that the size of the engine describes the volume of air that an engine can ingest during one cycle (2 revolutions). A 3000 cm3 engine has 1.5 times the volume of a 2300cm3 engine. You would think that this higher capacity to ingest air would be able to generate about 1.3 times that amount of power over the smaller one. If an engine is tuned to actually ingest an amount of air equal to its displacement at a particular operating point, this engine is considered to have achieved a 100% volumetric efficiency. Our air cooled Porsche engines came from the factory with volumetric efficiencies in the low to mid 90% range. Given that the air pumping capacity of an engine is not only a function of volumetric efficiency but also of speed, one would think that just spinning the engine to a higher speed would increase the airflow and allow it to make more power. It is true that higher engine speeds can result in increased airflow, but it is not so easy to just spin the engine at a higher speed since mechanical limits on engine parts reach their limits and catastrophic failures can result. In that case, building a 7000 rpm engine is easier than building an 8000 rpm engine and crossing the 9000 rpm threshold on a 2 valve Porsche engine is a challenge that may be cost-prohibitive for many. A better plan may be to go back to figuring out how to get the volumetric efficiency up so that we can get the most air into the engine at the highest speed we dare to operate it at (reliably and safely). So how can we get more air into the engine than what the actual volume of the engine allows as suggested by volumetric efficiencies above 100%??? This is where things get interesting and therefore a little more technical. We need to touch on a few basic principles of physics to put this into context.

The first thing that we need to understand is that getting any gas into or out of a system (like an engine) requires some energy, since by itself it will not go in. The intake in the classical Otto cycle uses atmospheric pressure to drive outside air into a lower pressure chamber (cylinder) created by a receding piston (matter always wants to go from high pressure to low pressure). This part of the process is using the higher "potential" energy state (pressure is a form of this type of energy) available in the atmosphere (which has about 14.7psi of pressure) that goes to a lower potential energy state created in the cylinder by the piston which was energized by the crankshaft using kinetic energy (from the crank). During this process, a column of air (in the intake tract) was set into motion and started moving into the cylinder following the receding motion of the piston. Once the piston reaches the bottom of the stroke and the pressure reaches the lowest point, it stops and starts moving back up the cylinder (which would now increase pressure rather than decreasing it). The column of air, however, is still is moving and has mass so it has momentum (mass times velocity equals momentum) and it does not want to just stop. Changing the momentum (stopping the air flow) will convert this energy from the column of air into pressure. The piston moving up will raise the pressure in the cylinder and if we would leave the intake valve open until the raised pressure in the cylinder is equal to the increased pressure required to stop that column of air we would have "trapped" more air than was otherwise possible in the cylinder. This is one ingredient to get above the 100% volumetric efficiency.

Now to another physical phenomena: let's take a column of air that is moving in a pipe. This air has velocity and there is a relationship between velocity (kinetic energy) and pressure (potential energy). There is a law in physics that states that energy can not be created or destroyed but can be converted from one form to another (i.e. from kinetic to potential to internal). Additionally, the "Bernoulli" principle states that there is a relationship between pressure and velocity as fluid (or air) flows over a surface. As the area contracts (in a pipe, or in our case, the port), the velocity of the fluid increases (thereby increasing the momentum), and as the area once again expands, the velocity will decrease and the pressure of the fluid (air) will increase. In a specially designed intake port, this principle can be used to produce pressures above atmospheric pressure, contributing to the volumetric efficiency rising above 100%.

Another physics principle that is relevant is the one that states that every time you change something (flow direction, velocity, etc.) there is a result created which can be simply described as losses (such as frictional losses). These losses cause as temperature increases (because kinetic energy was changed to internal energy- heat- rather than potential energy), and the losses happen at a rate that is faster than the change in the speed of the flow of air. Because of this, the losses need to be kept "in check" to avoid losing the benefits that we are trying to generate with high speed ports. Additionally there is a limit to the flow that can be "pushed" through a given area and this limit is governed by the speed of sound which is solely a function of the temperature of the fluid (hot air has a higher limit than cold air etc.). In engineering jargon this is referred to as the "choke point". The choke point occurs when the velocity of the air reaches the speed of sound. Air flowing inside an intake port experiences significant "frictional losses" once the velocity exceeds about 65% of the speed of sound. The port approaches the choke point and the existing pressure difference (between the outside and inside the valve) is insufficiently high to drive more air into the cylinder.

In summary, to achieve the highest volumetric efficiencies, the intake and the exhaust ports need to be designed specifically, and the other variables that control the airflow in and out (i.e. cam timing, exhaust system and piston geometry) need to be designed to work within the system as well.  That is what the Elite Engine Systems are carefully engineered to do.