



Turbo response time and high rpm flow is enhanced on the Audi 2.7T engine with a collector tubular exhaust manifold design from our exhaust division, AWE Fabrication.

Our design utilizes T304 stainless steel tubing, CNC cut flanges, heat shield brackets, OEM sensor ports, and anti-reversion collectors with pulse generator technology.



Collector style vs. Log style

One of the purposes of an exhaust manifold on a turbo charged engine is to act as a exhaust gas delivery device from the cylinder head to the turbine side of the turbo.

The exhaust gas expelled from the engine's combustion chamber by the piston is known as an exhaust pulse.

The turbo uses the energy present in the exhaust pulse to produce boost, so the faster and more efficiently the manifold can deliver exhaust pulses from each cylinder to the turbo, the quicker the turbo will spool up and produce boost.

There are two basic styles used when designing an exhaust manifold: collector style and log style.

The stock 2.7T manifold is classified as a "log style" because of the way that each exhaust port in the cylinder head discharges its exhaust pulse into a long single tube running the length of the manifold.

A log style manifold design works much differently than a "collector style" design. We have chosen a collector style for our exhaust manifolds. A collector style manifold keeps each cylinder's exhaust pulse separate until they merge at a single point called a "collector".

While compactness and economical manufacturing are advantages to the log style manifold design, there are multiple performance disadvantages.

Careful 3D modeling of the available space in the manifold area of the 2.7T engine bay allowed us to set the overall parameters of our tubular collector design.

Collector style manifold overview

To understand why a collector style manifold executes the job of delivering exhaust pulses better than a log style, let's first take a look at the basic layout of a collector style manifold.

On a collector style manifold, the exhaust pulse from each cylinder travels from the cylinder head, down each manifold primary tube, and to the manifold collector. The pulses then merge and travel down the manifold secondary tube to the turbine side of the turbo.

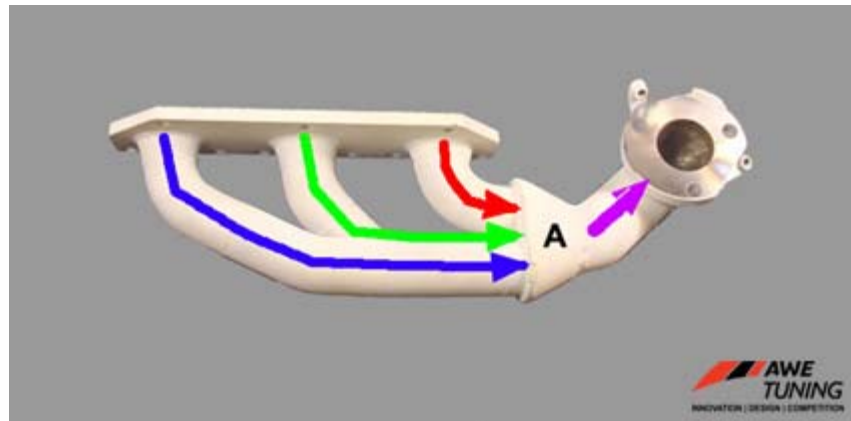


Figure 1: Exhaust flow paths of the AWE Tuning 2.7T collector manifold

In Figure 1 above, exhaust pulse paths are individually highlighted in blue, green, and red. The collector is at point A, and the merged path of the three exhaust pulses is highlighted in purple.

The basic idea behind keeping each exhaust pulse separate to the collector is to control and minimize the turbulence created when the exhaust pulses merge. Uncontrolled turbulence equals lost energy, as the exhaust gas pulses lose their direction and cannot deliver their full punch to the turbine. With a design that creates turbulence inside the manifold, energy is wasted, creating heat instead of spinning the turbine.

Log style manifold overview

Now that we understand how a collector style manifold flows, let's look at the stock log style as a contrast:

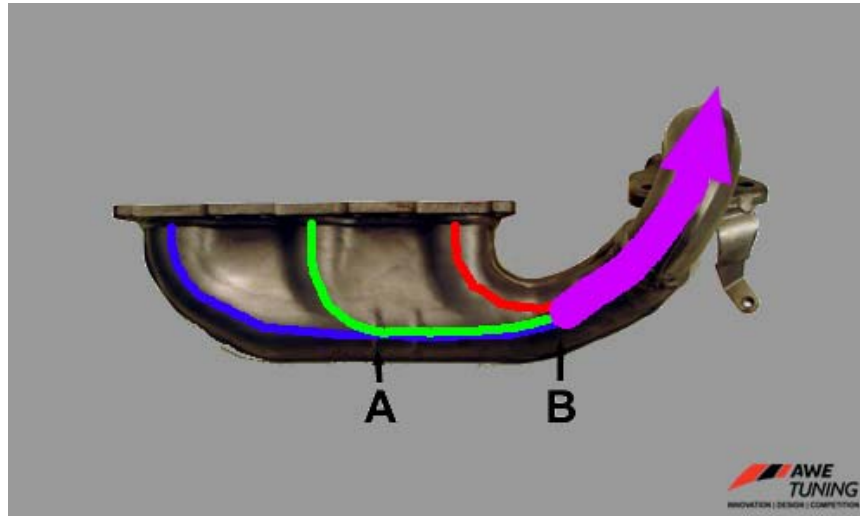


Figure 2: Flow path of stock Audi 2.7T exhaust manifold

Figure 2 shows the individual exhaust pulse paths of the stock Audi 2.7T exhaust manifold, highlighted in blue, green, and red. Notice how the blue exhaust pulse path merges with the green exhaust path at point A, and both blue and green finally merge with the red path at point B.

At each merge point, the velocity of the individual exhaust pulse as it travels toward the turbine is disrupted by the incoming exhaust pulse from another cylinder. Remember that the energy found in the secondary path of the manifold, highlighted in purple in Figure 2, is made up of the energy combined from the pulses traveling down each of the primary paths. In a log design, energy is lost at point A due to the turbulence created from the two pulses merging.

Reduction of turbulence means less wasted energy

To recap, a collector manifold style is superior to a log manifold style on the 2.7T V6 in the basic fact that turbulence is limited to one point instead of two, maximizing the energy potential to the turbo. This results in faster turbo spool up, and potentially more energy to create boost if requested by the fuel injection computer.

Besides the minimization of lost energy, however, reducing turbulence also has another desirable effect: the creation of a freer flowing exhaust path for the engine.

Freeing up the exhaust path properly

Now that we see how a collector style manifold is always going to be less turbulent than a log style, let's see what other elements can maximize the exhaust flow.

A less turbulent exhaust path means less work the engine has to do to "expel" the exhaust gases from the combustion chamber, which results in more energy going to the creation of power.

A properly designed collector style exhaust can help an engine in its job of evacuating exhaust gasses from the combustion chamber, minimizing the potential power energy that is normally lost in this process. This also means more of the exhaust gas is expelled on each exhaust stroke of the crankshaft, which is known as cylinder scavenging.

There are several techniques that can be employed to reduce turbulence and encourage exhaust flow.

The following sections will discuss the individual components of the AWE Tuning manifolds and why they are superior in design to the stock manifold's.

First, let's get acquainted with the components that make up the stock manifold. Most people do not realize that the factory 2.7T exhaust manifold uses a tubular design and is not cast metal. Below (Figure 1) is a cross sectional picture of the stock Audi 2.7T exhaust manifold, with an explanation of its various components:

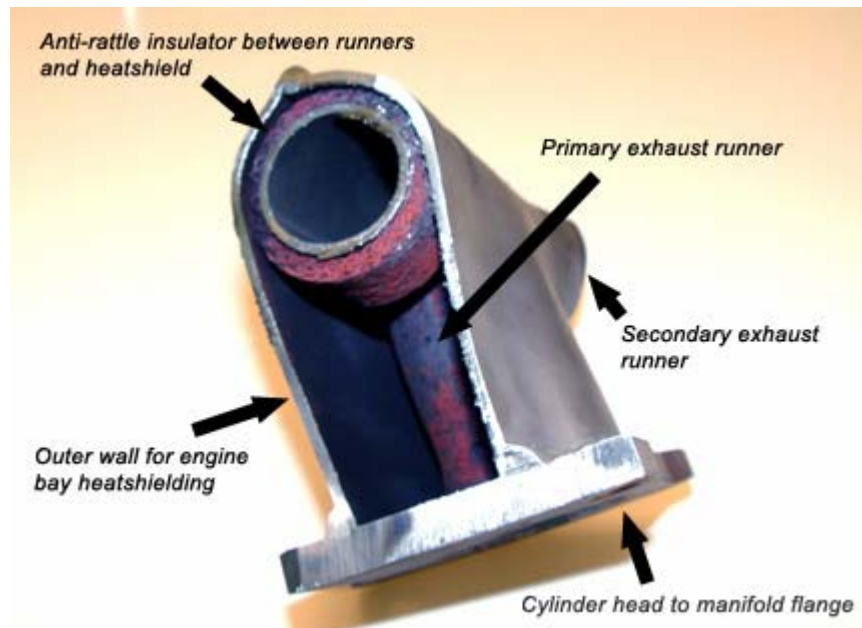


Figure 3: Cross section of stock Audi 2.7T exhaust manifold

Primary Runner Flow Theory

It is possible to create a flow path for the exhaust pulses that provides more than just an enclosed chamber to transport the gasses from cylinder head to turbo. By carefully sizing the tubes that the pulses travel in, one can reduce energy loss and thus closely maintain the speed at which the pulses travel the length of the manifold.

The primary runners of the stock exhaust manifold are sized too small to properly transport the increased exhaust gas mass seen when dramatically increasing power on the 2.7T engine. The small tube size creates a restriction in the exhaust path, making the engine work harder to expel the exhaust gasses from the combustion chamber. Increasing the size is required to minimize this restriction, however, there is a limit to how large the runners should be. Fitting the biggest tube possible is not desirable in this area of the manifold.

Increasing the tube diameter decreases the pressure found in the tube for a given exhaust mass. Decreasing the pressure too much by using too large of a tube can result in a loss of pulse velocity, which defeats the whole purpose of trying to improve the manifold design.

How does pressure keep velocity high? By introducing a larger chamber at the end of the runner, known here as the collector, the pulses can be "encouraged" to flow down the manifold primary. Gas under pressure will travel towards a location of lower pressure. If the primary tubes are too large, too much initial pressure is lost, and the velocity effect created by the differing pressures between primary and collector is reduced.

The key is to use a primary tube size that presents a reduced restriction vs. stock, but allows the gasses to travel at enough pressure to keep the velocity high.

As shown in the previous section, the stock manifold has no central collector, nor is the secondary runner diameter any larger than the primary runner diameters. Thus, there is no pressure differential that promotes gas velocity.



Figure 4: Comparison of primary runner diameters. Stock is pictured on the left, AWE Tuning on the right. The AWE Tuning primary runners are only 15% larger than stock, which is sufficient for ~475hp on the 2.7T when mated to a proper collector design.

Collector Theory

As demonstrated in the previous section, the key to maintaining pulse velocity from the cylinder head to the collector in a manifold is by providing a proportionally sized collector in relation to the primary runner diameter.

However, the design of the collector itself can play a large role in what happens to the exhaust pulses after they reach the collector. A collector can do much more than just provide a central meeting place for the individual cylinder exhaust pulses. The shape and length of a collector, in conjunction with the secondary runner, can promote a venturi effect, which positively affects the velocity of the exhaust pulses heading towards it in the primary runners.

Individual exhaust pulses reach the collector at different times due to the way that a four stroke engine work. For one rotation of the V6 crankshaft, while one pulse is entering a collector, two other ones are at different points along the primary runner lengths of a manifold. When a pulse enters the collector, it expands due to the greater volume found there. The localized expansion of this exhaust pulse creates a suction effect on the other primary runners that converge at the collector, thus further helping the exhaust pulses in those runners to maintain as much velocity as possible. **This is the definition of the "pulse generator" technology that is used in the AWE Tuning collector manifolds.**

However, just like how the exhaust pulses under pressure in the primaries "seek out" the relatively low pressure collector, the pulse that is expanding in the collector will try to enter the other primary runners at the collector. This obviously negates the above pulse generator effect, as the expanding gas from the collector entering the other primary exits would then present a restriction to the pulses moving down the primaries, instead of helping them.

Thus, a necessary component of a pulse generator collector is an **anti-reversion** bulkhead. This is essentially a wall present in the collector design that presents a barrier to the expanding gas in the collector, discouraging it from entering the other primaries. Keeping the expansion in the collector and not in the other primaries that are trying to deliver their exhaust pulses is the critical ingredient in pulse generator collector technology.

Thus, a collector must be much more than just a central meeting place of the individual exhaust pulses. Without pulse generation and anti-reversion techniques, a collector can actually slow down the exhaust pulses in the primaries.

Final destination: secondary section

Even though a collector needs to be more than just a central meeting place in a manifold, it still is a central area where three exhaust paths converge (in a V6 manifold). Thus, there must be a properly sized exit path for this convergence area, or there is the risk of turbulence and flow restriction. The exhaust pulses may arrive at the collector at different times, but they remain there long enough that there is an overall increase of exhaust gas volume at this point as other pulses arrive, depending upon engine rpms.

The stock manifold uses the same diameter for the secondary runner as the primary runners, even though there is potentially three times the gas mass that needs to be moved through this area. This is an obvious source of restriction.

The dramatically larger secondary diameter of the AWE Tuning manifolds necessitates modified heat shields, which are provided with each set.

AWE Tuning manifolds use a proportionally sized secondary runner with a tapered collector transition. This results in less turbulence and restriction, promoting good gas velocity to the turbine. The secondary is another area where too big a runner can result in localized restriction due to pressure loss, just like the primaries.



Figure 5: Comparison of secondary runner diameters. Stock is pictured on the left, AWE Tuning on the right. The AWE Tuning secondary runner is ~50% larger than stock, which is appropriate given the proportional increase of gas volume in this area of the manifold. The stock secondary diameter is the same as the primary diameters!

Other design notes and conclusion

A collector style manifold is not as compact as a log style, and space is severely limited in the area of the exhaust manifolds of the 2.7T engine bay. We therefore opted for a high quality thermal barrier coating on the manifolds. Our partnership with Swain Tech coatings allowed us to use all the available space without the need for an outer heatshield wall.

The Swain Tech coating on our manifolds is a unique ceramic thermal barrier commonly used for industrial and aerospace applications such as rocket nozzles, missile nose cones, and jet turbine parts. Swain Tech has modified this ceramic to work on AWE's exhaust parts. This multilayered coating has a melting point of over 4,600 degrees F and has superior insulating properties. Swain Tech's ceramic is nothing like the shiny or colored coatings found on the market; this is a true ceramic thermal barrier.

Special attention was given to the turbo flanges of the AWE Tuning manifolds, too. The stock flanges contain threaded openings for the factory EGT probes. We faithfully reproduced the angle and position of the stock probe openings in order to ensure that the EGT probes would have proper placement in the exhaust stream. Proper placement ensures accurate readings to the fuel injection computer.



Figure 6: CNC cut flanges provide proper EGT probe placement with the AWE Tuning manifolds. Top is stock, bottom is AWE Tuning.

In conclusion, the AWE Tuning collector style manifolds minimize turbulence downstream compared to the factory log style, which maintains ultimate exhaust gas velocity. Maximum gas velocity in the primary runners of the manifold promotes more efficient evacuation of the combustion chamber, known as cylinder scavenging. The collector design itself works as a physical barrier to prevent the exhaust gases from flowing backwards. The secondary runner, after the collector, is nearly 50% larger than stock, eliminating the bottleneck found in the factory design.

The AWE Tuning manifolds are the secret to the broad powerband of the AWE Tuning RSK04 2.7T full turbo kit, yet benefits can be realized even using our manifolds with stock turbos.