Aeromotive, Inc. Technical Bulletin #501

From: Aeromotive Technical Department

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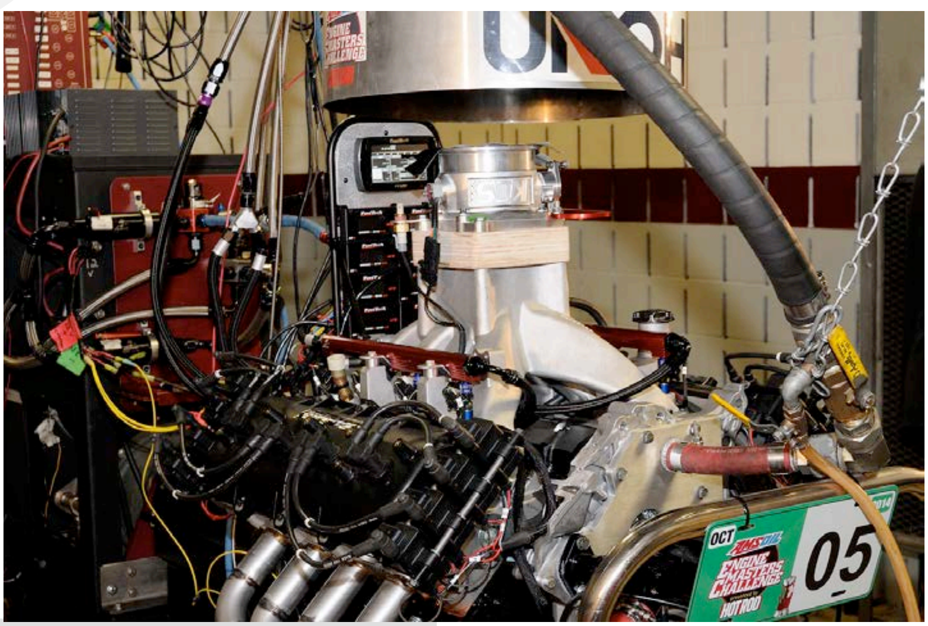
Re: **Fuel Pumps and Horsepower: What to consider when selecting a fuel pump.**

The critical factors that effect fuel pump selection are numerous. In the past, fuel pump manufacturers have rated their offerings based on gallons-per-hour, free-flow (no test pressure), and with no reference to test voltage. In the real world, this gave no indication of the horsepower that could be supported by such a pump. By choosing to assign a horsepower rating, along with publishing flow information at actual pressures and realistic voltages, Aeromotive has again broken the mold and raised the bar for the industry. Examining the Aeromotive catalog reveals that each pump carries several HP ratings on the basis of application and use of power adders. The purpose of this tech bulletin is to discuss the variables that effect how much HP a fuel pump can support and what to consider when evaluating this for the engine/power adder combination.

The key variables that determine which fuel pump is suitable for a particular engine combination are:

- Engine flywheel horsepower.
- Fuel Type, including gasoline, ethanol and methanol.
- Engine fuel efficiency, commonly referred to as BSFC or Brake Specific Fuel Consumption.
- Maximum fuel system pressure and the pumps flow volume at that pressure.
- Available voltage at the pump under engine load and the pumps flow volume at that voltage.



The first step in choosing the correct fuel pump for any engine is to establish how much horsepower will be made and the amount of fuel required to support it. To be safe, start by estimating HP on the high side and efficiency or BSFC for the fuel of choice on the low side. A typical gasoline engine will use less than 1lb of fuel to make 1 HP for 1 hour, so expect the BSFC number to be less than 1. Different engine combinations, power adders, opting for ethanol or methanol fuel, even fuel octane ratings and different tuning approaches, will have a profound impact on BSFC. Consider these factors carefully.

You may use the following information as a guideline, however these are simply observations based on experience. The recommended method of establishing BSFC is through proper flywheel dyno testing. Given the popularity of alcohol fuels, we've updated this Tech Bulletin to include ethanol and methanol.

Gasoline: Baseline

- Naturally aspirated engines are normally most efficient with a BSFC from 0.4 to 0.5 lbs/hp/hr.
- Nitrous combinations use a little extra fuel and often develop a BSFC from 0.5 to 0.6 lbs/hp/hr.
- Forced induction engines are usually least efficient and BSFC ranges from 0.6 to 0.75 lbs/hp/hr.

Ethanol: Plan for 30-35% more fuel consumption than gasoline burning engines.

- Naturally aspirated engines are normally most efficient with a BSFC from 0.6 to 0.7 lbs/hp/hr.
- Nitrous combinations use a little extra fuel and often develop a BSFC from 0.75 to 0.8 lbs/hp/hr.
- Forced induction engines are usually least efficient and BSFC ranges from 0.85 to 0.95 lbs/hp/hr.

Methanol: Plan for 100-200% more fuel consumption than gasoline burning engines.

- Naturally aspirated engines are normally most efficient with a BSFC from 0.9 to 1.1 lbs/hp/hr.
- Nitrous combinations use a little extra fuel and often develop a BSFC from 1.2 to 1.3 lbs/hp/hr.
- Forced induction engines are dramatically less efficient with BSFC from 1.8 to 2.0 lbs/hp/hr.

The following examples are based gasoline BSFC factors. The concept applies to all fuels and may be demonstrated by substituting the appropriate BSFC values from the list above for any fuel you choose.

Using 650 HP, let's figure the fuel requirement for the most vs. the least efficient engine combination.

- 650 HP multiplied by a .4 BSFC equals 260 lbs of gasoline.
- 650 HP multiplied by a .75 BSFC equals 487 lbs of gasoline.

As you can see, the amount of fuel required to support two different engines, each making the identical amount of HP but with very different fuel efficiencies, virtually doubles the volume of fuel required! Note: It is equally important to consider BSFC when determining minimum injector size. To calculate, divide the lbs of gasoline required by the number of injectors used. If you are estimating, it pays to be safe. Many engine builders will add a percentage to total fuel pump volume for safety and then divide the minimum injector by .8 in order to target about 80% injector duty cycle. This allows consistent injector performance, cooler operation for enhanced durability and leaves about 10% for unexpected power.

For example:

- 650HPx.4 = 260lbs. 260lbs/8 injectors=33lbs/hr. 33/.8=41lb/hr injector @ 80% duty cycle.
- 650HPx.75=487lbs. 487lbs/8 injectors=61lbs/hr. 61/.8=76lbs/hr injector @ 80% duty cycle.

It is imperative to consult with an experienced engine builder when estimating HP and making these calculations. There's a lot at stake and errors can result in serious harm to the engine and those around it.

Determining the fuel volume necessary for a particular engine is the first step in selecting a fuel pump. If the combination is naturally aspirated, does not use rising fuel system pressure and has a correctly sized alternator in good working condition it may be OK to stop here. If not, there's still more to consider.

The second step is to establish what the base fuel pressure will be and if, as with forced induction or certain "dry nitrous" kits, pressure will be required to change with engine load. How does fuel pressure affect pump delivery? You can bet that as system pressure goes up the pump' volume will go down.

To illustrate this, take one of the most popular and efficient EFI pumps on the market, Aeromotive' A-1000 part #11101. Lets examine various pressures to demonstrate the effect this has on flow volume:

- Carbureted, Naturally Aspirated, 9psi base pressure and 13.5v,
  Flow volume 931 lbs/hr. HP capacity 1,862 FWHP @ .5 BSFC.

- EFI, Naturally Aspirated, 43psi base pressure and 13.5v,
  Flow volume 794 lbs/hr. HP capacity 1,588 FWHP @ .5 BSFC.

- EFI Blown with 20psi boost, 1:1 Regulator, 43psi base pressure, 63psi plus boost, and 13.5v,
  Flow volume 714 lbs/hr. HP Capacity 1,098 FWHP @ .65 BSFC

- EFI Blown with 10psi boost, 4:1 FMU, 43psi base pressure, 83psi plus boost and 13.5v,
  Flow volume 634 lbs/hr. HP Capacity 975 FWHP @ .65 BSFC

- EFI Blown with 6psi boost, 8:1 FMU, 43psi base pressure, 91psi plus boost and 13.5v,
  Flow volume 602 lbs/hr. HP Capacity 926 FWHP @ .65 BSFC

Measuring a high efficiency Aeromotive pump such as the A-1000, from 9psi to over 90psi, flow volume is reduced a total of 35%. Comparing volume at 63psi for a high boost kit with correct injectors to 91psi for a low boost application, with small injectors and an FMU, volume is reduced by 16%. Clearly the effect of rising fuel pressure has a notable impact on flow volume. What is not shown (and rarely published) is the devastating impact this has on less efficient, traditional pumping mechanisms used by much of the competition. It is obvious that eliminating unnecessary fuel pressure rise, e.g. removing an FMU and installing the correct injector, increases flow, maximizing the HP potential of any fuel system.

This brings us to our third fuel pump performance factor; voltage supply as measured at the fuel pump terminals. Voltage to an electric motor is like fuel pressure to an injector, more pressure in equals more volume out. Higher voltage at the pump terminals increases motor torque, resulting in more rpm and an increased flow volume for a given pressure. To illustrate this, the A-1000 Aeromotive fuel pump at 80psi will see an 22% increase in volume when voltage is increased from 12v to 13.5v. This factor is often overlooked and can make or brake pump performance, especially at high pressures. The key here is to figure flow at voltage based on whether an alternator is used or not. Often deleted on drag cars, the lack of a correctly sized and properly functioning alternator is vital to consider when choosing a fuel pump.

Please note, regarding Aeromotive' published pump/HP ratings, these recommendations are based on gasoline as the fuel, an injector that permits 43psi base fuel pressure, and sound tuning practice. Graphs for all Aeromotive fuel pumps illustrating flow volume across a reasonable pressure range can be found at www.Aeromotiveinc.com, and in our catalog. Please consult this information or call our tech line for further assistance and thanks for choosing Aeromotive!