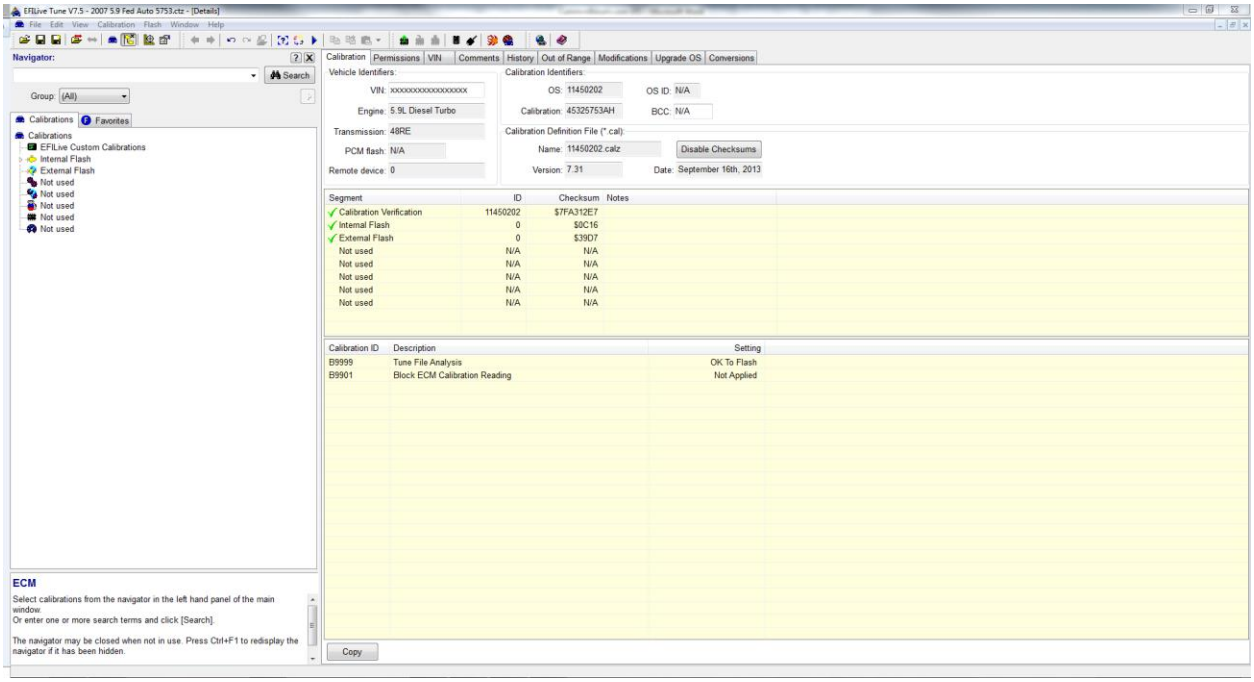
Tuning Basics

By Mike Dorsey

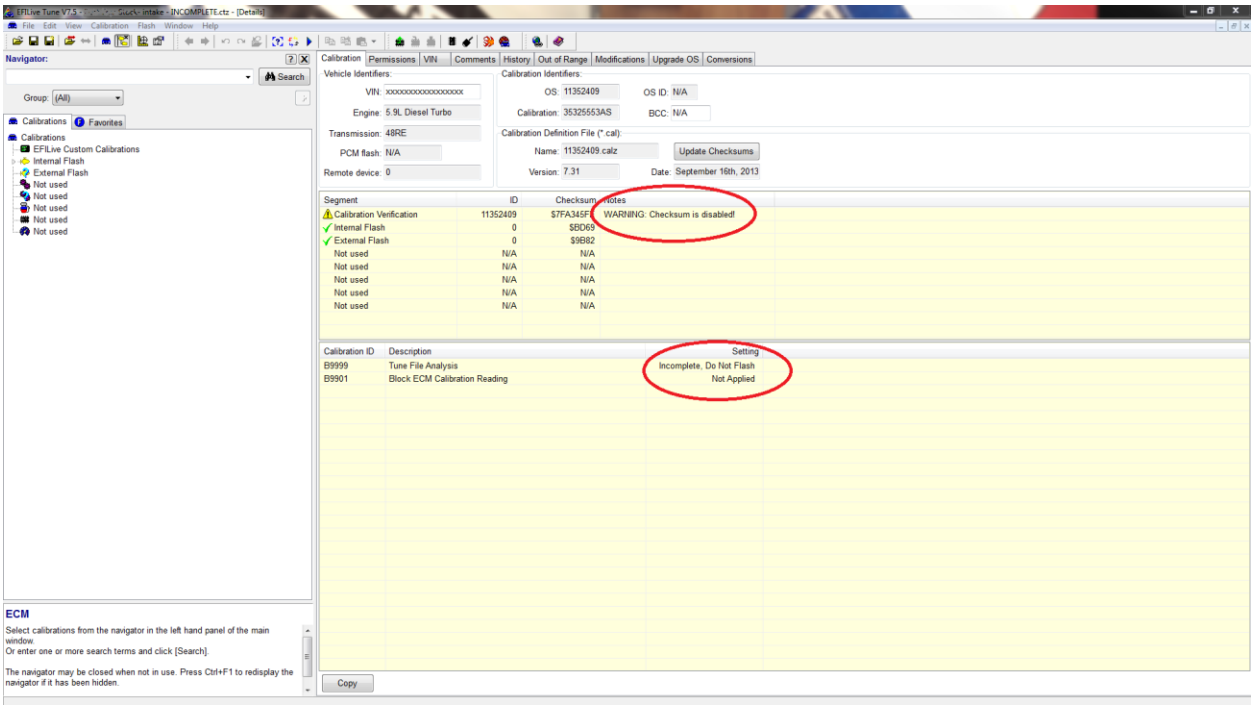
I have had quite a few questions lately about getting started on tuning with EFILive. I thought that I would just go over some of the basics to help you get a good base tune built. These basics are a compilation of experience that I have gained working with modified diesels over the last 14 years, and making hundreds of dyno runs on many different platforms and configurations. There are many tables that can be modified, and I will not be able to go over all of them. This should be enough information to get you going, and you can later experiment with other tables after you have a good base tune to build off of. I will use a Cummins 5.9L tune as an example. For the most part, the same general principals will apply to other diesel engines and other tuning platforms as well. This information can be used for those of you who are tuning with UDC, or making some adjustments to your 6.7L Cummins. There is more than one way to skin a cat, and more than one way to build a tune. This is just an example of one of the many ways. The different tables used in this document are some quick examples that I came up with to demonstrate what a table can look like, and not what I actually use in my tunes. This is not meant to be an all-encompassing tutorial; I will just hitting the high points along the way.

Before you start building your own tune, be sure that your stock tune is safe to use. If you truck has been tuned before it is extremely important to check the B9999 tune file analysis to be sure that it is "Ok to Flash" and NOT "Incomplete, Do Not Flash." Also, check the calibration verification to be sure that the checksums have not been disabled. If you are unable to use your tune because of the above issues, you can find a clean stock version of your tune from: www.tunefiledepot.com. The safest way to find the correct tune file for your truck is to match up the year of your truck, transmission type, operating system, and calibration number of your stock tune. Having said that, in most cases operating systems can be easily swapped for various reasons. When using a new tune that was not read out of the truck, you will need to change the VIN number, and confirm the anti-theft settings.

This is an example of a tune that is ok to flash:



This is an example of a tune that is NOT ok to flash:



It can be a little intimidating at first looking at all of the different tables in your tune. It will take some time to go through everything and make adjustments, then drive and data log the truck, and make more adjustments. To simplify the process I have narrowed it down to 4 main tables (or types of tables) that have the largest influence on the tune: timing, duration, pressure, and limiters.

Timing

The saying "timing is everything" definitely applies to building a good tune. I cover timing first because in my opinion it is where most of your time should be spent getting a tune dialed in, and likely the most important table in the entire tune. This table can contribute to mileage, response, smoke output, power, torque, EGT's, and engine durability. The built in timing calculator is a very important tool to help you build a table that is going to work well for the rest of the tune. There is no magical timing value or percentage that can be used on every tune. Values will vary between a tow, street, and a race tune, and will also be different for engines with larger injectors, turbos, etc. An important rule of thumb here is to start out low, and work your way up. The reasoning behind this is because too little of timing can cause white smoke, poor response and low power, which isn't good for an engine, but is not detrimental. On the other hand, too much timing can cause extreme cylinder pressures and possible engine damage, as well as additional black smoke.

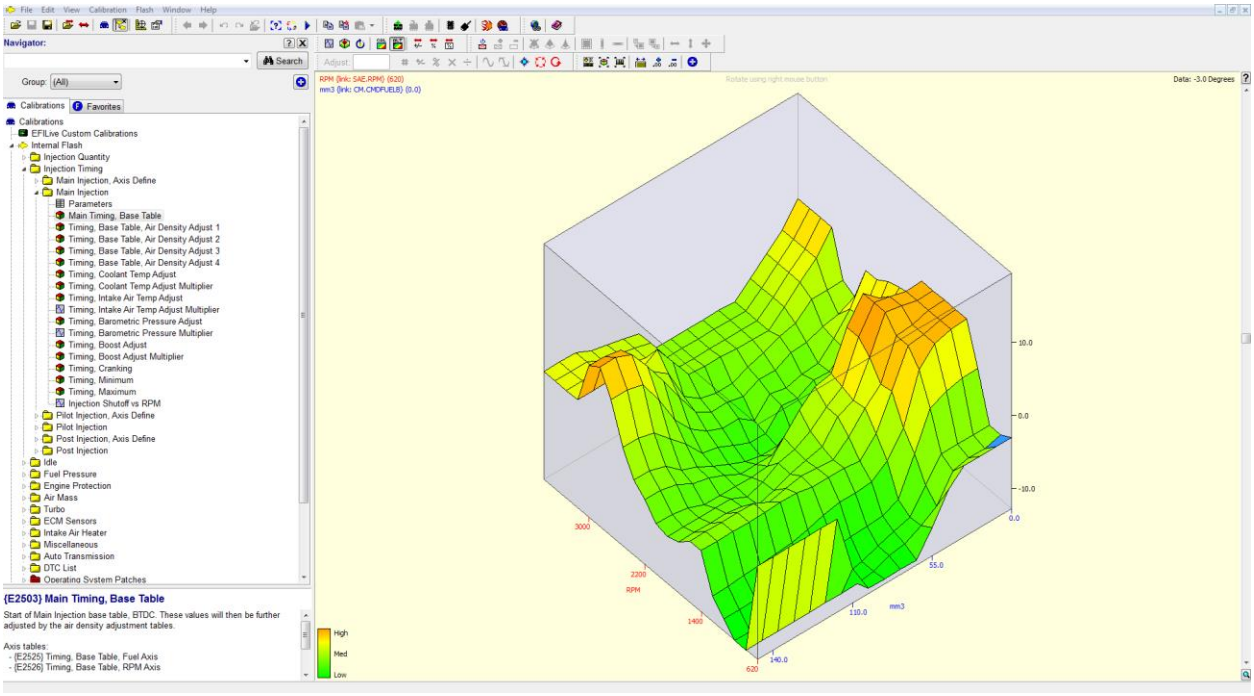
It is important to keep in mind the load of the engine, the speed of the engine, and the amount of fuel being injected when making changes. Fuel takes time to be injected and burn. The faster the engine spins, increasingly more timing will be required for the combustion event to take place at an efficient point in the pistons cycle. When the quantity of fuel increases, so does the time that it takes to be injected and burn. This, however, doesn't always mean that more fuel equals more timing. Look at your stock tune for example. The highest percentage of fuel injected before TDC is in the light load cruising range. This is done for mileage and response reasons. It is possible because the small amount of fuel injected in this area needs to create sufficient cylinder pressure, and there is little load on the engine so it is able to push the piston down with ease. On the other end of the spectrum would be higher load and lower engine RPM. Again, looking at the stock timing table you can see that this is where some of the least amount of timing is located, and is well after TDC. Timing is shifted from before TDC to after TDC due to the increasing amount of load, or force that is required to push the piston down on the power stroke. It is much more efficient for the main injection event to be just powering the piston down under heavy load at low rpm, and not creating unnecessary cylinder pressure by starting before TDC.

I am sure that some of you have seen something about a 50/50 split for the main injection event using the timing calculator. This means that half of the injection event occurs before TDC, and the other half after TDC in a continuous shot. This 50/50 split will work in some parts of the tune, but not in other parts of the tune. There are some areas that you will be well below this, but you really shouldn't go far above this to avoid high cylinder pressure. A maximum of about 25* in the upper RPM's is a good safe general rule of thumb for the average street tune. A hot performance or race tune will likely need

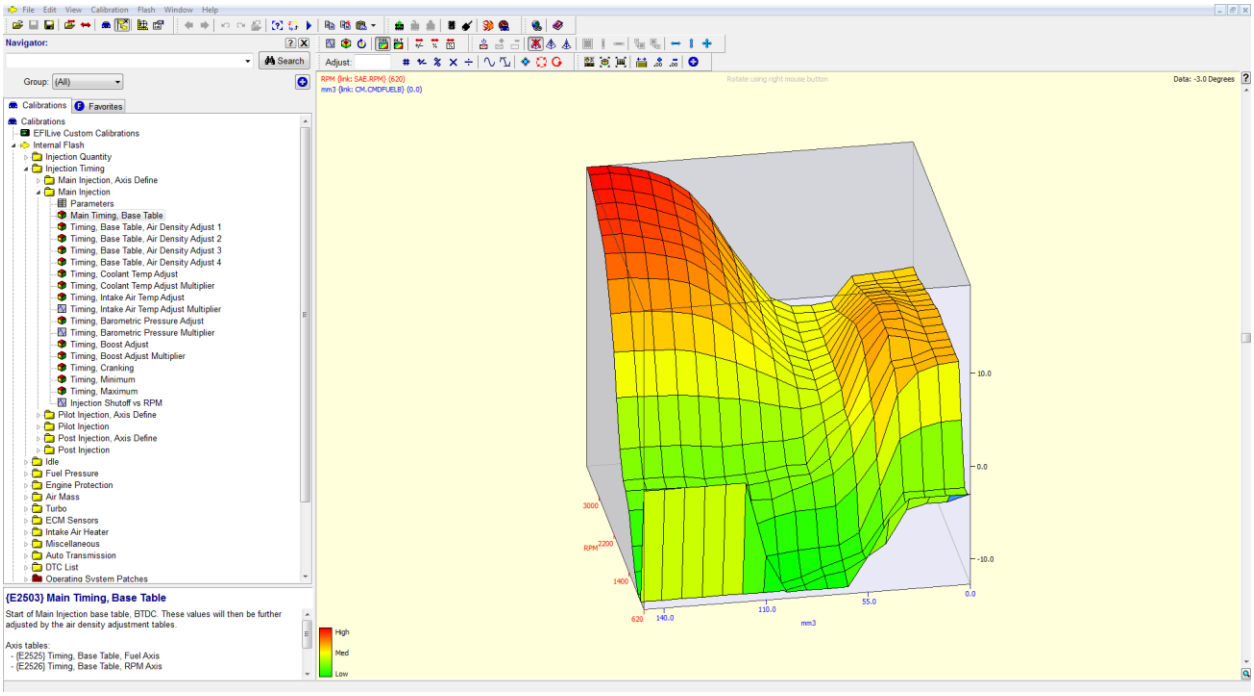
around 27* or so depending on the maximum duration and RPM. There are exceptions to every rule, as a very high RPM engines will need to be set outside these limits a bit because of ignition delay.

The two main influences on the main timing table that you will be working with are the duration, and pressure tables. Duration generally has more of an effect on main timing than pressure does. Pilot quantity and timing also has a direct influence on main timing. Post injection will be influenced by any main injection timing changes if it is still being used, as its timing tables are based on time after the main injection event. For the most part, pilot timing and quantity can be left alone. Another part of the tables that can be left alone on most tunes would be the idle range.

This is an example of an unmodified main injection timing table:



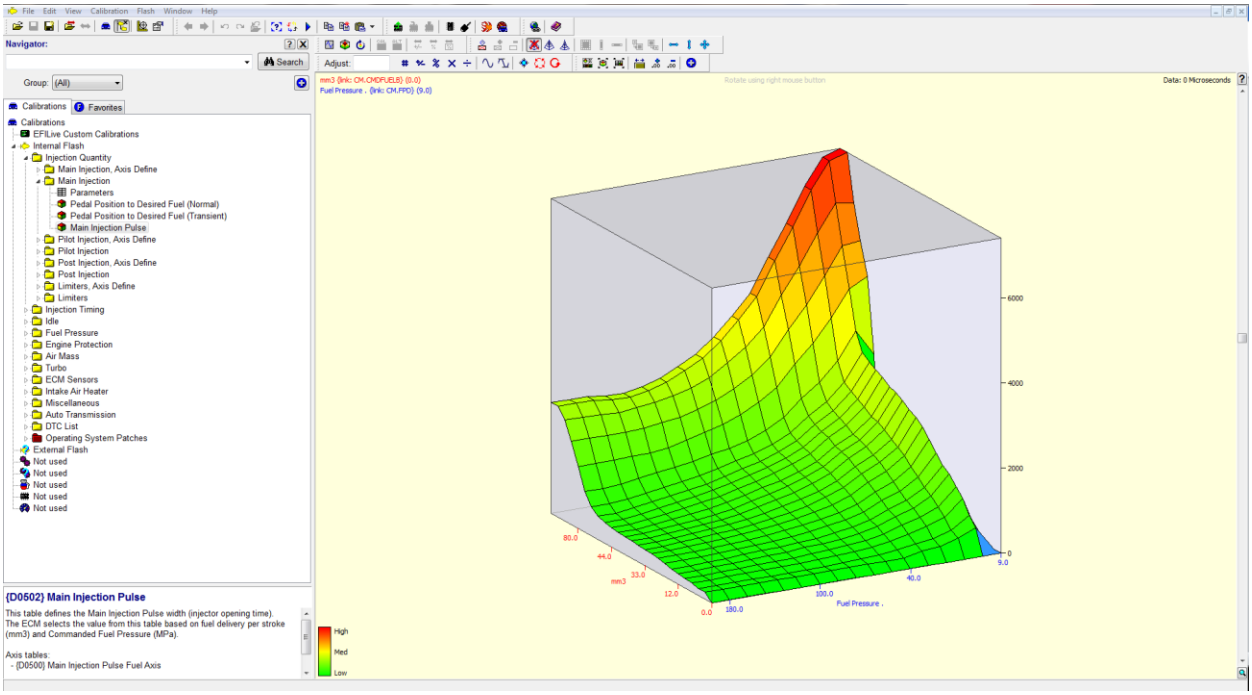
This is an example of a modified main injection timing table:



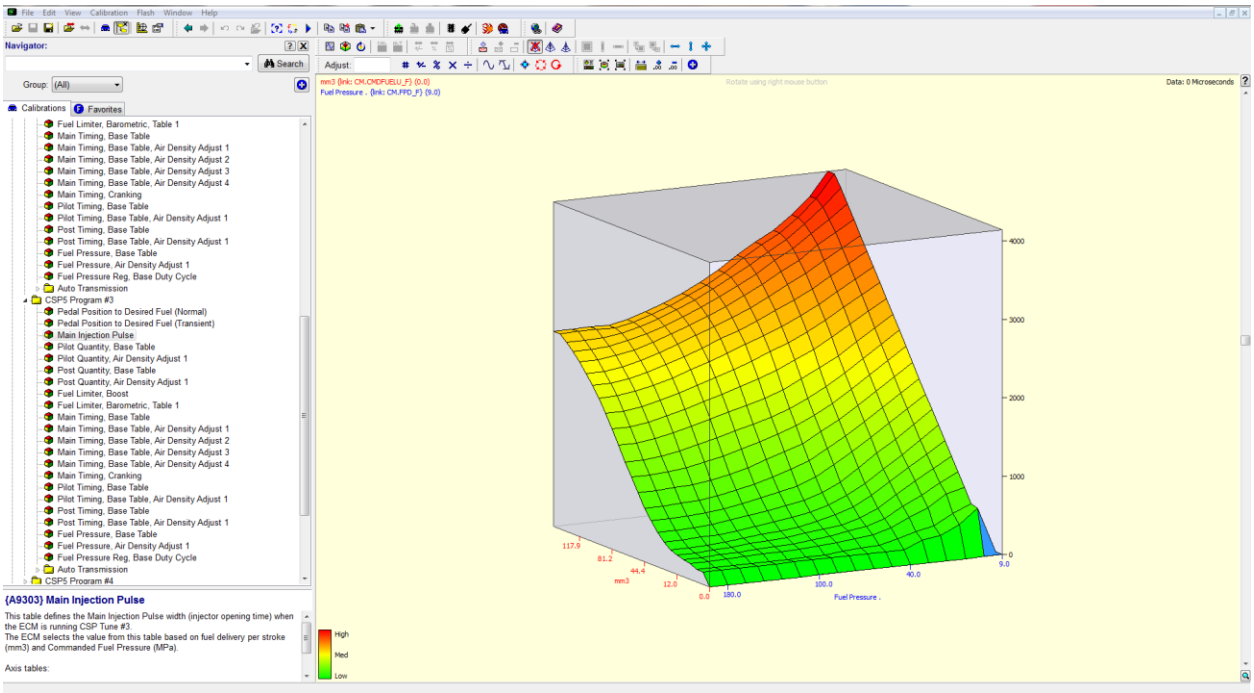
Duration

Injection duration is one of the first tables that I modify because it sets the stage for what kind of tune is being built. If you are working on a tow tune it will likely have less duration throughout the entire table compared to a street or a performance tune. Additional duration can be added to just the upper mm3 areas, or throughout most of the table depending on what you are trying to accomplish. I recommend starting out by adding a little duration (25 - 50us) to the maximum mm3 cells, and blending that into the rest of the table. Be sure to compensate for any duration changes in your timing table. Also, adding more duration can also add smoke. So, some compensation may need to be made in the limiting tables as well. Your maximum duration values may range from about 1950us to about 2900us depending on if it is a tow or race tune, and the supporting modifications of the truck. It is difficult to say what a “safe” upper limit is because what is safe for one truck, driver, or application may not be safe for another. Assuming that the drivetrain and fuel system can support it, and that the pyrometer is not ignored, I would say that around 2700-2900us is a somewhat safe upper limit for a race tune until you really get a good feel for the truck and tuning. Maximum values should always be worked up to in smaller increments, and data logged, for best results. Additional power can likely be made above this limit, but care should be taken as cylinder pressure and EGT’s can become high.

This is an example of a mildly modified duration table:



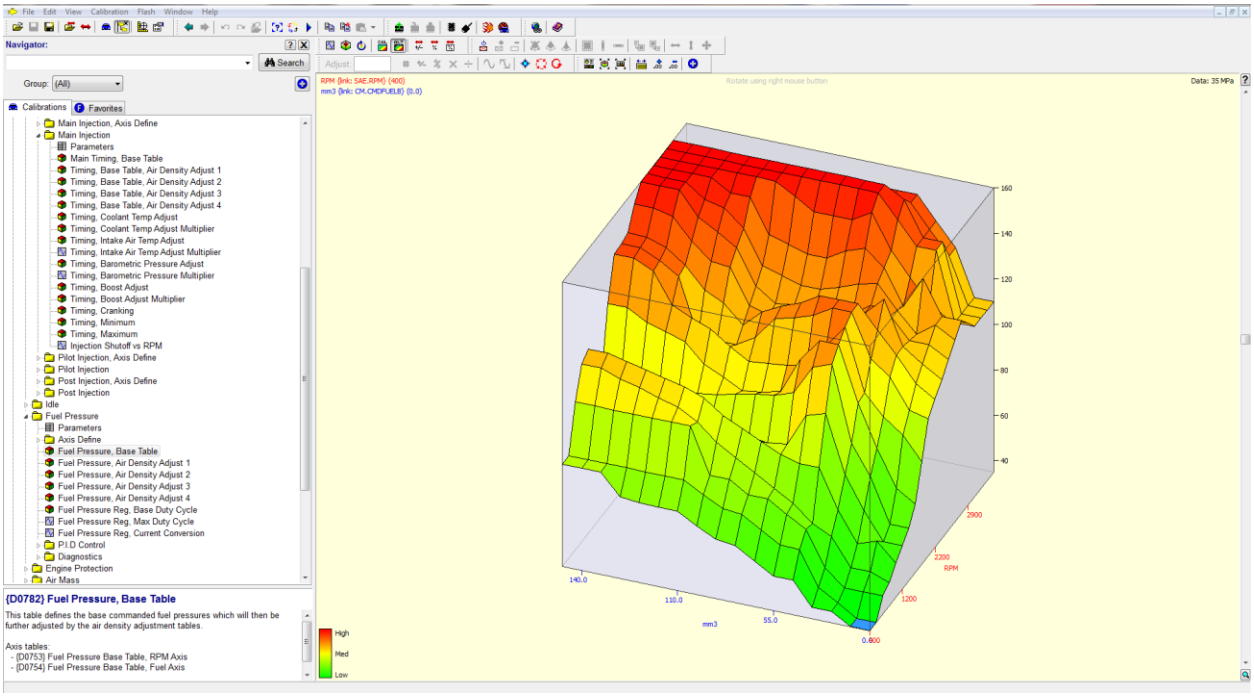
This is an example of what a more highly modified duration table can look like:



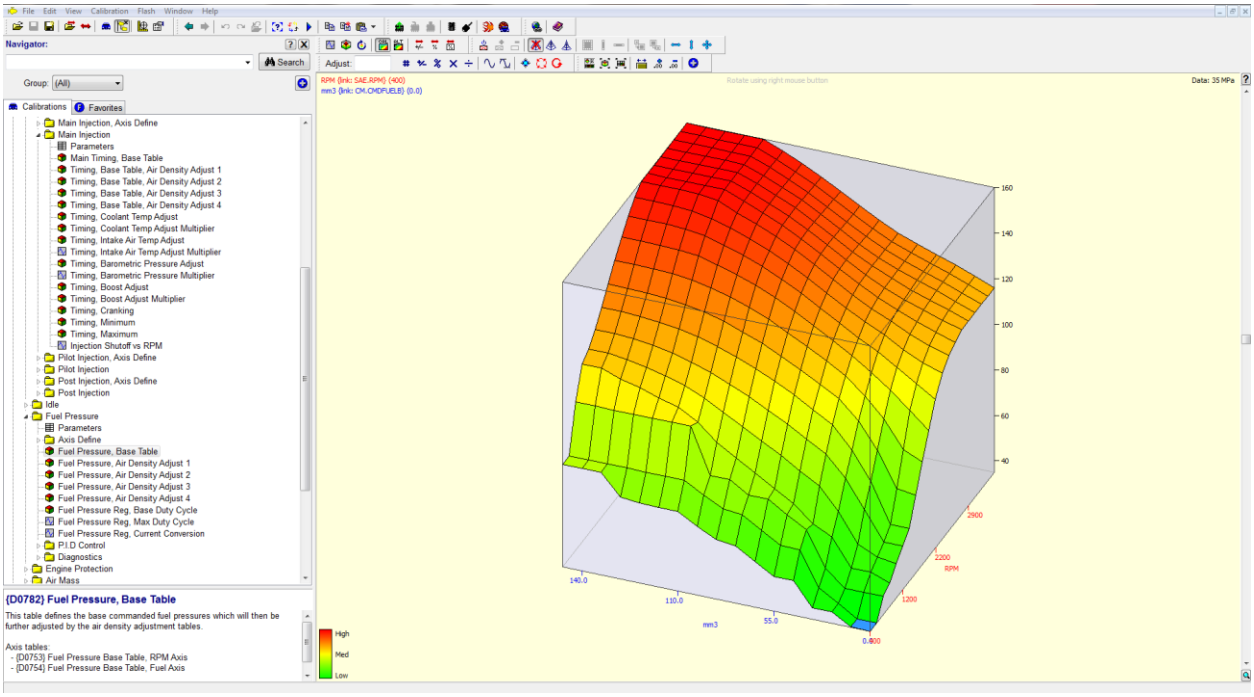
Pressure

Fuel rail pressure is another one of the more important tables to be modified for a good quality tune. It can seem like more pressure is better, but that is not always the case. Increased pressure can allow for better response, reduced smoke, and more power. But, it can also create more smoke if not compensated for, can cause increased engine noise, and also lead to injector damage. I recommend staying with the factory maximum of 160mpa for 99% of tunes on 5.9's. Additional power can likely be made by going up to a maximum of 180mpa for an all-out race tune, but I am not going to recommend that. This does not directly apply to 6.7's as they run up to 180mpa from the factory. Smoothing out the table is the first step as it is rough to begin with. After that you can fine tune it for optimal response without creating excessive smoke, or engine rattle. Once the pressure table is dialed in it can be left alone for the most part, and used in many different kinds of tunes such as your tow or street tune.

This is an example of an unmodified fuel rail pressure table:



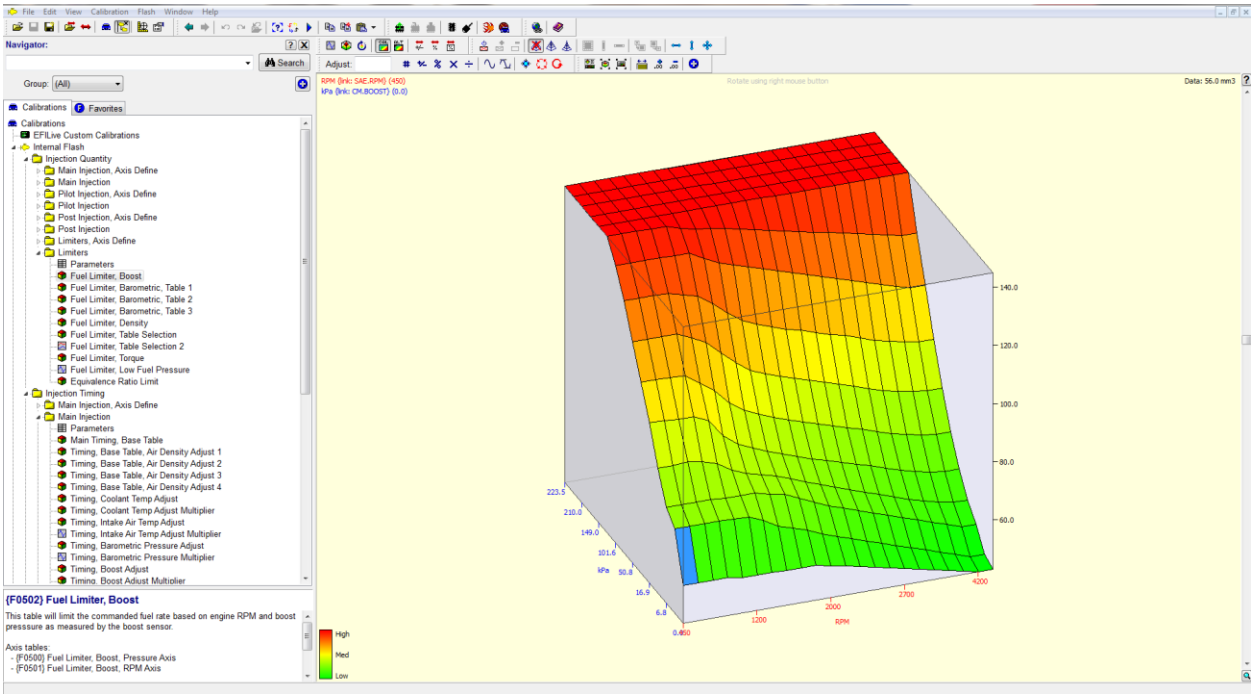
This is an example of a modified pressure table:



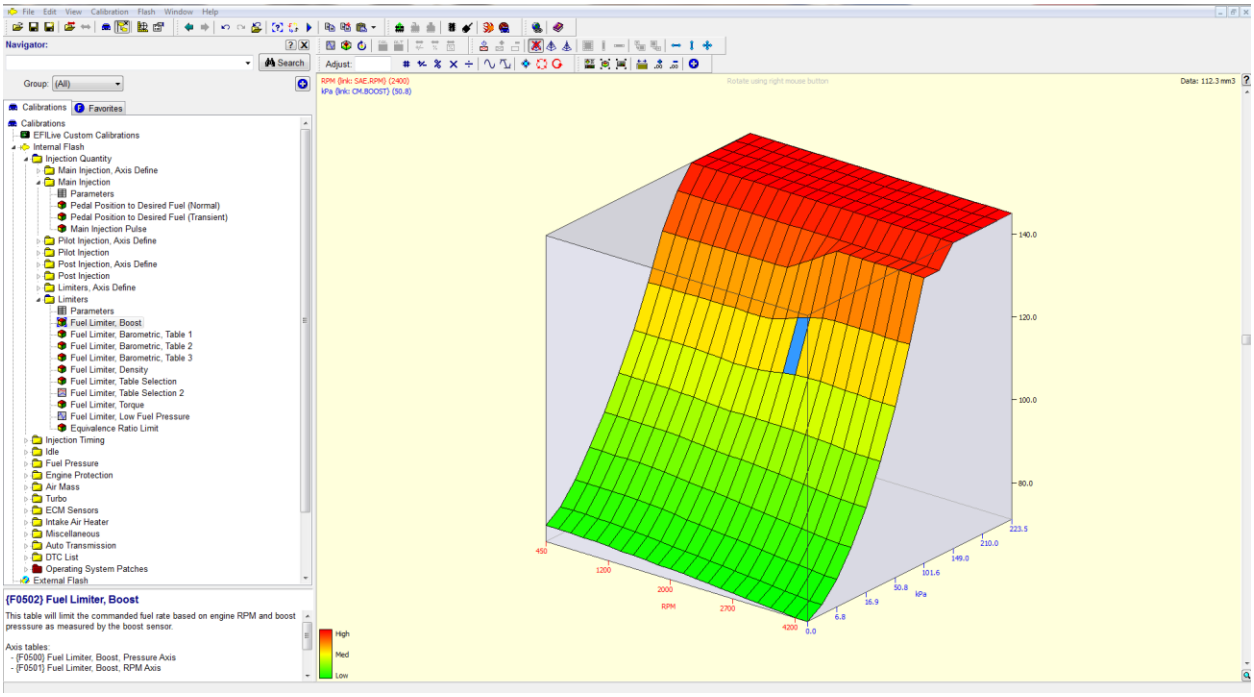
Limiters

The last of the four “main” tables to adjust, but not least, is the Limiting tables. Most limiters can be found in the “Limiters” folder. Other limiting tables can be found throughout the tune. Depending on how the rest of the tune is setup, you may rely heavily on these tables for proper operation and engine safety, or they may have only a small influence on the tune. Some of the more important limiters for engine safety would be RPM, maximum timing, and maximum fuel rail pressure, for example. Limiters like these should be set so that regardless how your tables are setup, the limiters will not allow your engine to be pushed too far. I do not like to absolutely rely on these tables, so care should always be taken modifying any table. Other limiters can be set to their maximum value so that they are not inhibiting the maximum fuel rate when you don’t want it to be limited. I generally control fuel rate with one or two limiters (boost limiter for example), and max the rest of them out so that they do not interfere with what I am trying to accomplish. This is a personal preference, and will vary depending on the type of tune being built, and your own tuning style. Additional mm3 of fuel can be allowed by the limiting tables to help with response and low-end torque. Too much fuel down low or before the turbo spools will of course create excessive smoke. So, remove a small amount of limiting (add fuel) at a time until the desired response is achieved. For the best efficiency, maximum fuel shouldn’t be allowed until the engine has the ability to burn it. This point will be different for each tune, as the overall quantity of fuel will be different for each tune. You can slowly reduce the boost pressure or RPM in which maximum fuel is delivered until you get the desired result without causing excessive smoke.

This is an example of a smoothed out or lightly modified boost limiting table:



This is an example of a mildly aggressive boost limiting table:



Here are a few other random notes: The post injections event is something that some want to disable right off the bat for several reasons - while I agree with this for the most part, it can also be helpful in some applications if used properly. When one change is made, often times it will need to be compensated for in another part of the tune. Duration must be compensated for by adjusting timing and possibly a limiter adjustment, increased boost can set a code/check engine light, and so adjustments need to be made in the turbo and DTC tables, and so on. Not all changes made in the tune will have results as expected. So data logging any changes made is very important to ensure that what you are commanding is actually happening. Just make one change at a time, log the change, and then make any needed adjustments, and repeat. Before too long you should have a tune that works well for you and your truck.

DISCLAIMER:

Gauges are highly recommended on any modified vehicle. Custom tuning is solely intended for race applications and for off road use only. I do not warrant that a tune is error free and will not be responsible, and be held harmless, for any/all injury or damage to persons or property resulting from use of aftermarket tuning and/or products. It is potentially harmful to a controller anytime it is flashed with a stock or modified tune. I am not held responsible for any controller failures. Buyer/installer assumes any and all responsibility for removing or modifying any federal emissions equipment, and programming consequences. Buyer/installer assumes any and all responsibility regarding local, state, and federal regulations regarding these products and their usage. This product may void your factory warranty. There is no warranty or guarantee of any kind expressed or implied in connection with a tune and its use. The usage of a tune is done so at your own risk. There are no returns whatsoever on tuning. By installing/using this product you agree to all and accept the above conditions.

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