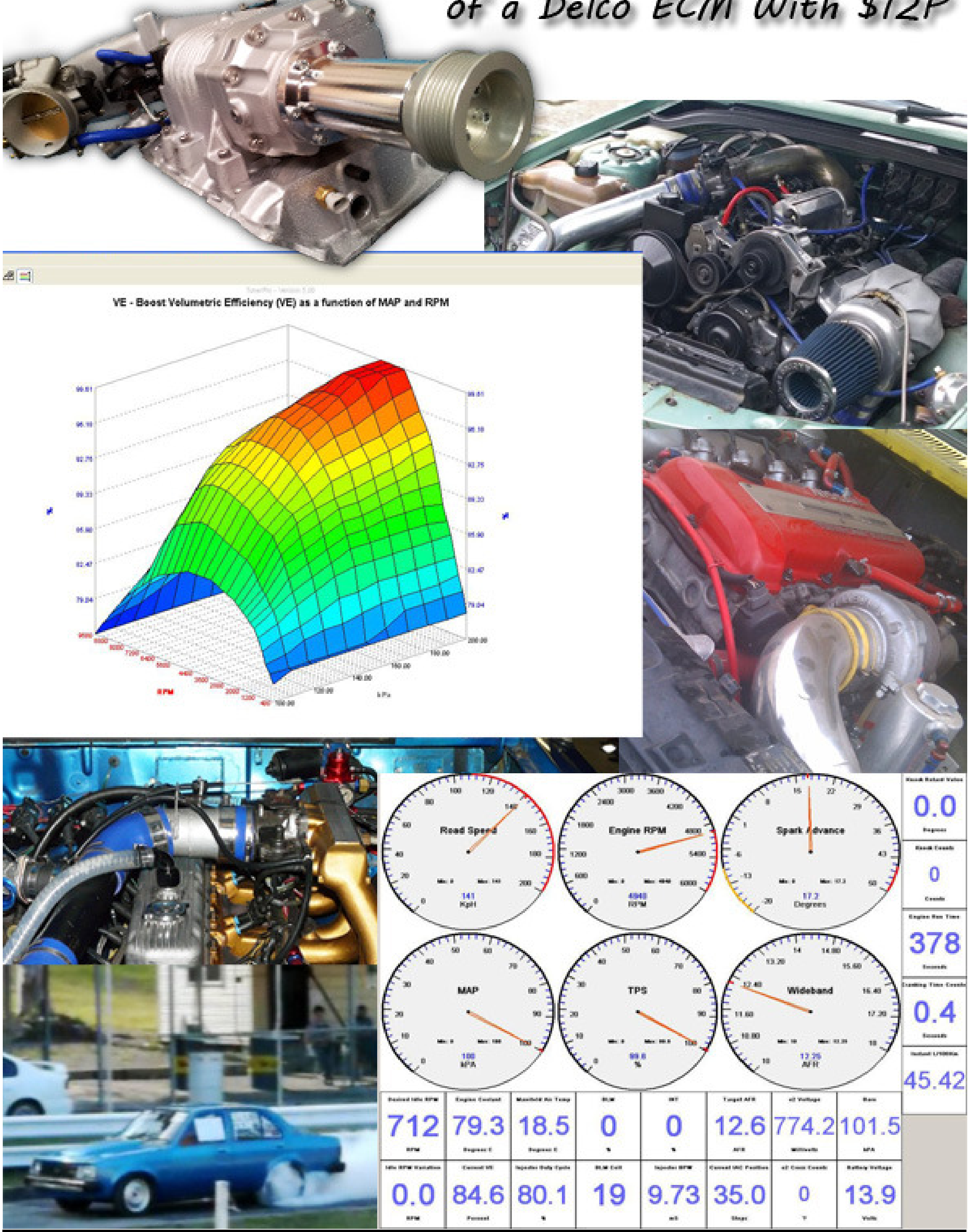
Basic Tuning

of a Delco ECM With $12P



BASIC TUNING OF A DELCO ECM - v1.02

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THE BASICS OF TUNING A DELCO ECM

Disclaimer: This document is based around tuning $12P code and as such is intended as a general guide only as different code bases have subtle differences and different models require different tuning techniques, this is also by no means a full manual for tuning a delco!
This also assumes the user has the ability to log data from the ECM through Tuner Pro V5 and has a wideband oxygen sensor installed on the motor with an analog input into the ECM.

Abbreviations:

- VE – Volumetric Efficiency
- AFR – Air fuel Ratio
- AE – Accelerator Enrichment
- DE – Deceleration Enleanment
- TP5 – Tuner Pro v5
- WOT – Wide Open Throttle
- BPW – Base Pulse Width
- IAC – Intake Air Control

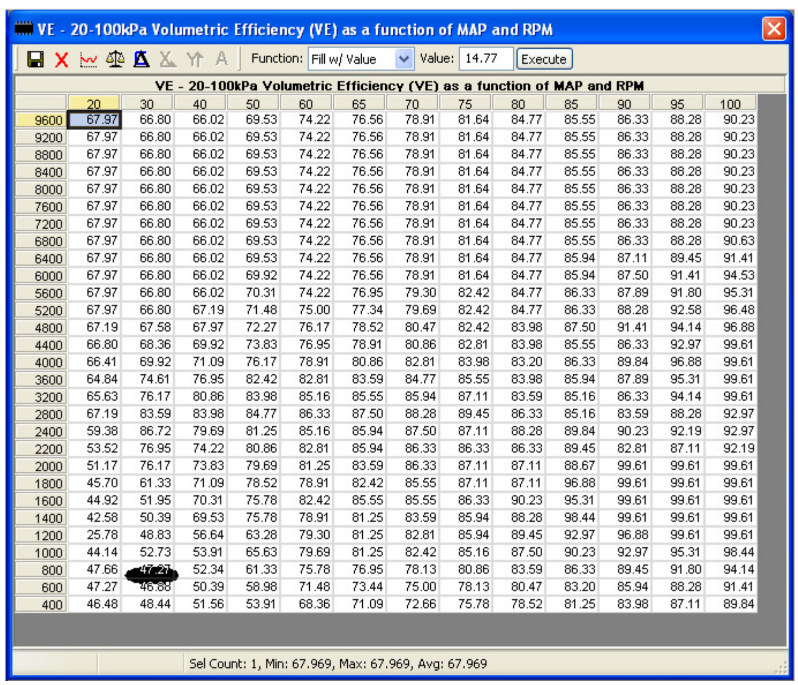
Tuning Fuel:-

First thing to do when wanting to tune an engines fueling needs is to get the engine up to temperature, because a lot of the changes made to fueling requirements are greatly affected by engine temperature. If the engine is not up to temperature there are numerous offsets that change the end result which means a lot of wasted time tuning a moving target.
Once the engine is up to temperature then you can start making changes.

The way you tune will depend on what options you have available to you, e.g. dyno or on the street, also weather you have a real-time tuning solution or not etc.
So for those of you who have a real-time solution this is by far the quickest setup, even if you are not on a dyno, get someone to drive the car for you while you sit in the passenger seat and tinker on the laptop.

As you can see here data tracing is enabled and this gives you a bubble over the current cell that the engine is running on. Using this you are then able to adjust the cell in question on the fly, so to do this you would have the dash displaying, or at least some sort of histogram or monitor showing AFR readings, this then gives you a reference to increase/decrease the current VE cell by.

The key to doing this is with a smooth throttle application, this lessens the chance of going in AE/DE mode, which will affect AFR readings.



VE - 20-100kPa Volumetric Efficiency (VE) as a function of MAP and RPM

	20	30	40	50	60	65	70	75	80	85	90	95	100
9600	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
9200	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
8800	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
8400	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
8000	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
7600	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
7200	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.23
6800	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.55	86.33	88.28	90.63
6400	67.97	66.80	66.02	69.53	74.22	76.56	78.91	81.64	84.77	85.94	87.11	89.45	91.41
6000	67.97	66.80	66.02	69.92	74.22	76.56	78.91	81.64	84.77	85.94	87.50	91.41	94.53
5600	67.97	66.80	66.02	70.31	74.22	76.95	79.30	82.42	84.77	86.33	87.89	91.80	95.31
5200	67.97	66.80	67.19	71.48	75.00	77.34	79.69	82.42	84.77	86.33	88.28	92.58	96.48
4800	67.19	67.58	67.97	72.27	76.17	78.52	80.47	82.42	83.98	87.50	91.41	94.14	96.88
4400	66.80	68.36	69.92	73.83	76.95	78.91	80.86	82.81	83.98	85.55	86.33	92.97	99.61
4000	66.41	69.92	71.09	76.17	78.91	80.86	82.81	83.98	83.20	86.33	89.84	96.88	99.61
3600	64.84	74.61	76.95	82.42	82.81	83.59	84.77	85.55	83.98	85.94	87.89	95.31	99.61
3200	65.63	76.17	80.86	83.98	85.16	85.55	85.94	87.11	83.59	85.16	86.33	94.14	99.61
2800	67.19	83.59	83.98	84.77	86.33	87.50	88.28	89.45	86.33	85.16	83.59	88.28	92.97
2400	59.38	86.72	79.69	81.25	85.16	85.94	87.50	87.11	88.28	89.84	90.23	92.19	92.97
2200	53.52	76.95	74.22	80.86	82.81	85.94	86.33	86.33	86.33	89.45	82.81	87.11	92.19
2000	51.17	76.17	73.83	79.69	81.25	83.59	86.33	87.11	87.11	88.67	99.61	99.61	99.61
1800	45.70	61.33	71.09	78.52	78.91	82.42	85.55	87.11	87.11	96.88	99.61	99.61	99.61
1600	44.92	51.95	70.31	75.78	82.42	85.55	85.55	86.33	90.23	95.31	99.61	99.61	99.61
1400	42.58	50.39	69.53	75.78	78.91	81.25	83.59	85.94	88.28	98.44	99.61	99.61	99.61
1200	25.78	48.83	56.64	63.28	79.30	81.25	82.81	85.94	89.45	92.97	96.88	99.61	99.61
1000	44.14	52.73	53.91	65.63	79.69	81.25	82.42	85.16	87.50	90.23	92.97	95.31	98.44
800	47.66	47.27	52.34	61.33	75.78	76.95	78.13	80.86	83.59	86.33	89.45	91.80	94.14
600	47.27	46.88	50.39	58.98	71.48	73.44	75.00	78.13	80.47	83.20	85.94	88.28	91.41
400	46.48	48.44	51.56	53.91	68.36	71.09	72.66	75.78	78.52	81.25	83.98	87.11	89.84

Sel Count: 1, Min: 67.969, Max: 67.969, Avg: 67.969

The next method is more suitable for single person tuning or for if you don't have real time gear to change as you drive. Pretty much all you need to do to get the information for this method is to set the laptop logging and go for a drive. Once you have finished save your log and then you have the information you need for making changes.

So what you need to do is load the log in TP5 and use the histogram view and play back the log with wideband histogram selected.

You will get something similar to this histogram (please note this is an E85 AFR table so the target AFR is 9.8) and these numbers can be simply plugged into an excel spreadsheet to work out percentage of change needed to the VE table.

Which view you use depends on personal preference, I like to use "average" view as this gives less chance of high or low points in the numbers.

History Tables

History Table: wideband — View: Running Average — Clear — Graph

wideband - MAP v

	20	30	40	50	60	70	80	90	100
400									4.867
600			7.967						
800		7.785	8.010	7.795	6.433		4.867	6.300	4.964
1000		7.894	9.209	8.640	8.067		9	6.267	9.200
1200		8.556	7.380	8.713	7.453	8.833	8.178	9.289	8.067
1400	8.596	8.803	7.240	7.400	8.625		8.767	8.578	8.533
1600	8.362	8.395	6.810	6.622	8.679	8.089	9.467		7.418
1800	8.173	7.133	6.467	6.867		6.133	7.717	7.983	7.236
2000	7.930			8.022	6.933	6.933		6.573	6.433
2200	7.853	7.200			6.667		6.600	5.933	8
2400	7.767			7.400		6.467			7.400
2600	7.617	7.200	6.367					7.533	
2800	7.733						7.067		
3000	7.567								
3200	6.833				6.267				
3400		6.267							

This histogram shows the target AFR which gives you an idea of what how much the VE table cells need to be changed to match the target.

From here you would use the VE Table calculator spreadsheet (which can be found on the forum) paste the current VE table into it, and the wideband histogram information and the spreadsheet will give you a new VE table to paste into your tune.

History Tables

History Table: Target AFR — View: Most Recent Sample — Clear — Graph

Target AFR - MAP v

	20	30	40	50	60	70	80	90	100
400									7.700
600			8.600						
800		7.700	7.700	7.700	7.700		7.700	7.700	7.700
1000		8.600	8.600	9.800	9.800		9.800	9.800	8.900
1200		8.600	9.800	9.800	9.800	9.800	9.800	9.800	8.400
1400	9.800	9.800	9.800	9.800	9.800		9.800	9.600	8.400
1600	9.800	9.800	9.800	9.800	9.800	9.800	9.800		8.400
1800	9.800	9.800	9.800	9.800		9.800	9.800	9.200	9
2000	9.800			9.800	9.800	9.800		9	8.400
2200	9.800	9.800			9.800		9.400	9.100	8.400
2400	9.800			9.800		9			8.400
2600	9.800	9.800	9.800					8.500	
2800	9.800						9.100		
3000	9.800								
3200	9.800				9.700				
3400		9.800							

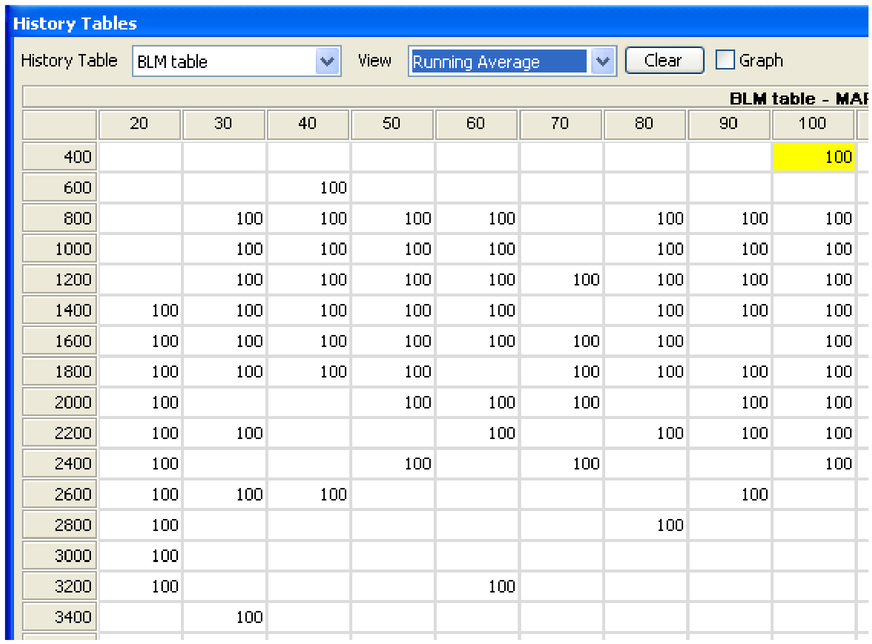
One thing to note is that from this method with driving around and logging you will get AE/DE affecting the AFR's so once you paste the new VE table into Tuner Pro it's a good idea to have a look at the 3D graph and see if there are any spikes in the table, these need to be smoothed to match the areas around it.

Another method of tuning fuel is to use BLM's which are part of the normal data stream when logging. The only problem with this method is that you can only really get useful information for closed loop areas of the tune (any cell that has a target AFR of 9.8 in the case of E85).

So the method is very much the same as logging wideband data but you use the BLM histogram table. How it works is that a BLM reading of 100 means the BLM in that cell is not influencing the VE table, however if there is a value of 95, this means that the VE value is too rich and the BLM is removing fuel, similarly a value above 100 means its adding fuel to get the VE to Stoichiometric value. Note – in $12P logging this value is a % so can be used to directly multiply the VE table value to make things easier.

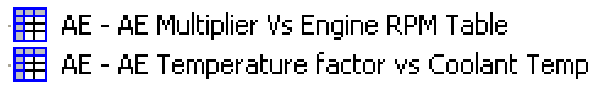
The one advantage of this type of tuning is that the ecm program needs to meet certain criteria before it will log a change in BLM from 100, this means that any values in this table outside of 100 can be safely used to change the VE table.

The only requirements for BLM logging is you need to have a narrow band o2 sensor installed.



	20	30	40	50	60	70	80	90	100
400									100
600			100						
800		100	100	100	100		100	100	100
1000		100	100	100	100		100	100	100
1200		100	100	100	100	100	100	100	100
1400	100	100	100	100	100		100	100	100
1600	100	100	100	100	100	100	100		100
1800	100	100	100	100		100	100	100	100
2000	100			100	100	100		100	100
2200	100	100			100		100	100	100
2400	100			100		100			100
2600	100	100	100					100	
2800	100						100		
3000	100								
3200	100				100				
3400		100							

The other part of fuel tuning is working on AE, this really needs to be done once the VE table is in the ball park otherwise VE can make an AE problem seem worse than it is. What you want to do is use a monitor log and be at a stable speed and throttle position so the wideband AFR is smooth, then put the accelerator down and take note if there is a lean spike in the wideband monitor, this will tell you if you need to richen the AE. If there is then you need to work out what settings to change. Similarly if there is a rich spike you need to lean areas out.



The two tables listed here are fairly straight forward, “AE Temperature Factor vs Coolant Temp” is used to change AE when the engine is warming up, and “AE Multiplier vs Engine RPM Table” is generally used when the engine is warmed up and you are trying to tune AE at certain rpms.

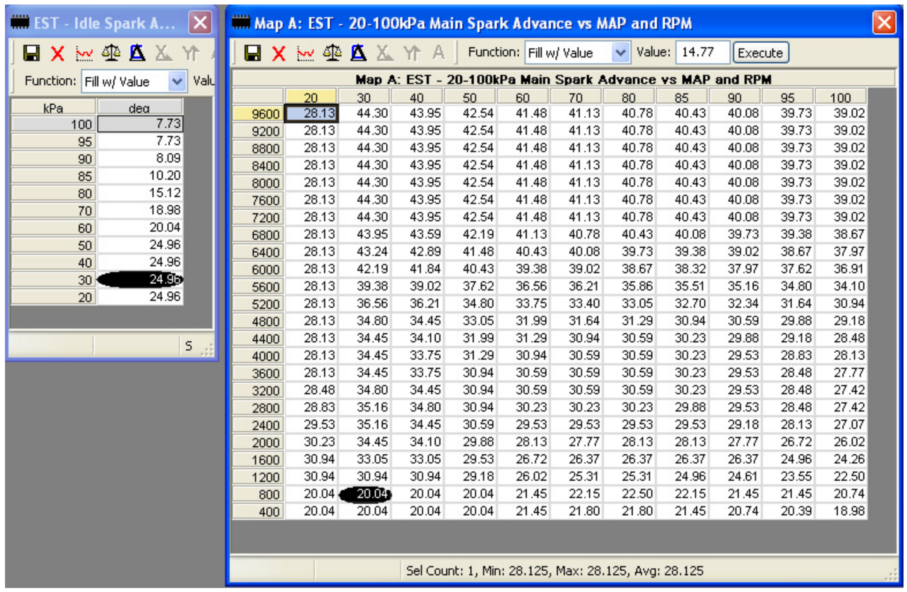
If your issue is occurring in between two rpm points it’s up to the tuner to work out which one to alter, and may require both being slightly altered. Alternatively, when tuning this try to get the rpms at the breakpoints in the table before you stand on the loud pedal.

These changes a lot of the time come down to trial and error, engines with big plenum manifolds will need more AE low in the revs but need less as revs rise. This is also something that differs with camshafts.

Tuning Spark:-

First thing that needs to be sorted out with tuning an engine is to get the idle spark sorted out, especially if you engine has a different camshaft or other engine work that will effect it, generally as a rule a bigger cam will be able to idle with more timing and it will usually be happier with more timing than less timing. Timing tuning can obviously be done in real-time or not but real-time tuning in this instance is REALLY handy.

You can see here that this engine is idling at 800 rpm and 30 kpa, so what you want to do firstly is get the idle and main spark tables the same, so here I would change the main spark table 400-800rpm cells to match the idle numbers or vice versa change the idle numbers to match the main table numbers. The main outcome here is to have all the numbers the same in the respective tables otherwise when the engine is switching between tables it will be changing the timing, this can often be seen as an engine at idle with the spark timing gauge jumping all over the place.



kPa	deg
100	7.73
95	7.73
90	8.09
85	10.20
80	15.12
70	18.98
60	20.04
50	24.96
40	24.96
30	24.96
20	24.96

Map A: EST - 20-100kPa Main Spark Advance vs MAP and RPM

	20	30	40	50	60	70	80	85	90	95	100
9600	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
9200	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
8800	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
8400	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
8000	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
7600	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
7200	28.13	44.30	43.95	42.54	41.48	41.13	40.78	40.43	40.08	39.73	39.02
6800	28.13	43.95	43.59	42.19	41.13	40.78	40.43	40.08	39.73	39.38	38.67
6400	28.13	43.24	42.89	41.48	40.43	40.08	39.73	39.38	39.02	38.67	37.97
6000	28.13	42.19	41.84	40.43	39.38	39.02	38.67	38.32	37.97	37.62	36.91
5600	28.13	39.38	39.02	37.62	36.56	36.21	35.86	35.51	35.16	34.80	34.10
5200	28.13	36.56	36.21	34.80	33.75	33.40	33.05	32.70	32.34	31.64	30.94
4800	28.13	34.80	34.45	33.05	31.99	31.64	31.29	30.94	30.59	29.88	29.18
4400	28.13	34.45	34.10	31.99	31.29	30.94	30.59	30.23	29.88	29.18	28.48
4000	28.13	34.45	33.75	31.29	30.94	30.59	30.59	30.23	29.53	28.83	28.13
3600	28.13	34.45	33.75	30.94	30.59	30.59	30.59	30.23	29.53	28.48	27.77
3200	28.48	34.80	34.45	30.94	30.59	30.59	30.59	30.23	29.53	28.48	27.42
2800	28.83	35.16	34.80	30.94	30.23	30.23	30.23	29.88	29.53	28.48	27.42
2400	29.53	35.16	34.45	30.59	29.53	29.53	29.53	29.53	29.18	28.13	27.07
2000	30.23	34.45	34.10	29.88	28.13	27.77	28.13	28.13	27.77	26.72	26.02
1600	30.94	33.05	33.05	29.53	26.72	26.37	26.37	26.37	26.37	24.96	24.26
1200	30.94	30.94	30.94	29.18	26.02	25.31	25.31	24.96	24.61	23.55	22.50
800	20.04	20.04	20.04	20.04	21.45	22.15	22.50	22.15	21.45	21.45	20.74
400	20.04	20.04	20.04	20.04	21.45	21.80	21.80	21.45	20.74	20.39	18.98

Once you have the two tables matched and blended into the rest of the main spark table you can start fine tuning idle spark numbers. You will generally find that the best timing for your engine at idle will give the most vacuum, so you want to increase or decrease the timing till you find the highest vacuum reading (lower kpa number).
Now that we have the idle timing sorted out the next step is tuning everything else ☺

Tuning cruise spark timing can be done a lot like idle, more vacuum = more economy and spark that is closer to the mark, the problem with this is it's hard to do if you are not on a dyno and is virtually impossible to do without a helper driving.

Tuning WOT spark is a lot harder, and really to get it right you need to do it on a dyno and find the point of maximum torque. Without a dyno you are able to get spark a lot better to suit engine mods, for the v6 guys it's a lot easier to tune spark as these motors are fitted with knock sensors, which is usually only found in HSV model V8's.
What you need to do is go for a drive, and log a WOT run and see if there is any knock retard in any areas, if there are you want to remove spark in the affected areas, generally I would remove 2-3 degrees from the knock area and then see if the knock retard is still being logged or not.

This is by far nothing scientific but you want to increase spark as much as you can at every load point till it knocks then remove 2-3 degrees from that point, this will be a close but safe way to tune spark as best as you can without being on a dyno.

The other things that can affect spark is fueling, if you have a tune that is lean this will generally knock sooner than it would if it was tuned correctly so it's important to get the fuel tuning at least in the ball park before trying to do any spark tuning.
NOTE: Please note any knock/pinging is generally not good for the engine so only do this if you are sure of what you are doing. It is highly recommended to get this done on a dyno by a professional to avoid engine damage.

Injector Changes:-

A lot of the times when doing modifications to your engine you require the fitment of larger injectors, and in my experiences I have seen a lot of people have all sorts of issues as they just rip out the stock 19lb injectors and bung some 24lb's in there and assume that's the end of the story – That is far from the case!
There are so many calculations in the tune that even a small change like 19 -> 24lb can make an engine that is happy all the time be a total pain in the butt.

The good news is once you comprehend how the injector settings work it's not that hard to dial in your new injectors to suit your engine requirements.

In a perfect world you should be able to use injector rate calculators (there is one on the forum) to offset your tune and then most everything else will work itself out from there. So firstly, you need to know as much details as you can about your injectors, for example a set of Siemens deka 80lb injectors have roughly 4 times the flow capacity of the standard 19lbers … BUT one big difference between the two is the voltage needed to open them, and when that voltage drops (e.g. alternator not charging) it changes the fuel flow of the injector – but we will come back to this later.

Firstly you need to get the injector rate set for your specific injectors. This is done in $12P with the following two scalars with MAP A being the default unless the map switch is connected.

Map A: Run A/F Param - Displacement/inj flow rate (Litres/Grams per sec)
Map B: Run A/F Param - Displacement/inj flow rate (Litres/Grams per sec)

So with the assistance of kinjflow calculator (found on the forum) you need to put in the following information:

- Lb/hr of the new injectors
- Cylinder size of the engine
- Fuel Type used (this will reference a fuel weights table to make the calculation more accurate)

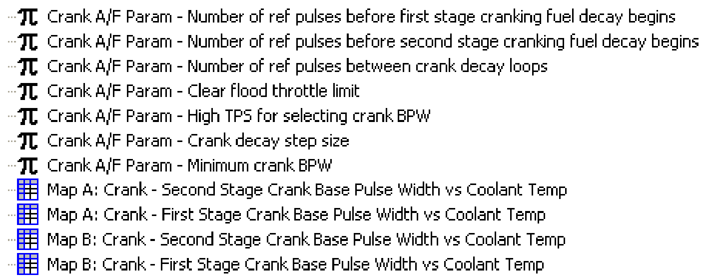
Lb/hr	19
Cyl Size	0.6292
Fuel Type	Petrol
Fuel Weight	0.7372
cc/min	194.8368
g/s Value	2.393895
KAL3 Value	0.208865
BPC	0.131
raw Value	0.131418
Kinjflow	0.131

Now the only problem with the Holden tunes is there has always been a bit of a fudge factor added to the injector rate, so for example here of a stock 304 motor, the injector rate is .147 in a stock tune, however as you can see the calculation has come to a conclusion of .131, this is the fudge factor and is something you really have to work out yourself, generally I have found if you make the lb/hr 1-2 lb less it gets you pretty close to what you need. In this case if you change the lb/hr to 17 it is spot on .147.

Now the best way to fine tune the fudge factor is to get the engine tuned in the WOT (90-100kpa) cells because you will find if the injector rate is too lean (smaller number) your VE cells will be maxed out at 100 and the engine will still be wanting more fuel at WOT. So the way to fix this is to change the injector rate in this example from .147 to .155 to get the highest WOT cells at about 90, this gives you plenty of room for adjustment and then if the rest of the VE table is too rich you are still able to lower the values to lean it out where needed.

So now we have our injector rates sorted out it is time to start fine tuning some of the other stuff and first thing you want to look at is the cranking BPW which is a fixed value in milliseconds for the injectors to fire while the engine is cranking. In the case of an 80lb injector replacing the standard 19lb, you are getting the same BPW when cranking the engine which means you are going to flood the engine VERY QUICKLY.

As you can see we have quite a few scalars and tables here, so firstly you have the two scalars which determine how long the engine cranks on the first stage table before it goes to the second stage table.
Next we have some settings that all relate to cranking fuel and flood clearing parameters.



Next we have the tables for the crank BPW - 2 for MAP A and 2 for MAP B, and for each there is a first stage and second stage table.

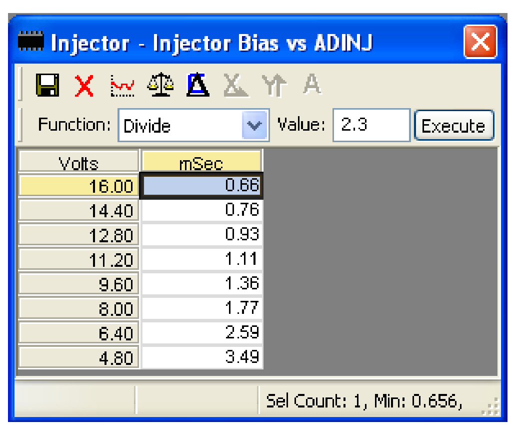
So in the case of the 80lb injectors you roughly want to divide the BPW numbers in these tables by 4.2, but also keep in mind if you are using different fuel like E85 or methanol these have very different requirements for the amount of fuel, for example you need approx 2.3 times more methanol than for petrol, so in this case you'd need to divide by 4.2 for the change in injector 19lb -> 80lb then you would need to multiply the results by 2.3 for using methanol.

How much to change these numbers for different fuels is not too hard to work out provided you know the stoichiometric ratio if the fuel:-

Petrol = 14.7
Methanol = 6.4 (14.7 / 6.4 = 2.296875)
E85 = 9.8 (14.7 / 9.8 = 1.5)

This is also how you would modify AFR tables to suit different fuels – select the entire table and use the divide function then the value would be 2.3 for methanol or 1.5 for e85, etc etc. (remember this needs to be done for any AFR table in the tune.

Once injector rates and cranking BPW have been sorted out the last thing to change is table which determines how the injector is affected when voltage drops. For some people this is not possible to determine unless it can be found on the manufacturers website or through flow testing. If you are lucky enough to find the information on the manufacturer's website then you need to adjust these values to get your setup dialed in. Now you may never need this table, but I have personally tuned a car with an intermittent alternator issue, and I can say first hand that a small drop in charge can significantly change fueling.
As you can see in this table, just going from 14.4v to 12.8v is a fairly large change in pulse time!

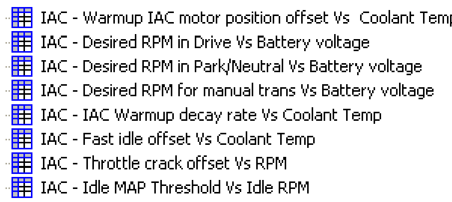


Tuning IAC Settings:-

A lot of people do not understand how important the IAC stepper motor is to the smooth running of the engine and all too often they will install a larger camshaft which requires the engine to be idling at a higher RPM and to achieve this they screw in the idle stop screw till it is where they want it.
While the engine will still run ok like this it's far from optimal and the end results can see random stalling when putting the car into gear and such.

The first thing that you need to check/adjust before going too far with IAC tables is the base IAC setting at idle. What you need to do is get the engine up to normal operating temperature (usually anything above 80 degrees C is fine) then with the use of the laptop logging on the dash screen you need to have the engine in park/neutral, turn off A/C, and then reference the IAC steps while screwing the idle stop in or out on the throttle body.

There is no hard and fast rules for what IAC step number to aim for but I generally try to aim for around 15-20 steps at idle.



From here you can then start looking at the IAC adjustment tables and as you can see there are quite a few.

- Warmup IAC Motor Position Offset Vs Coolant Temp
  This table is used to change the warmup rpm settings of the engine, so if you find your engine needs more rpm when it's cold then you can increase these numbers to get it right.
- Desired RPM Park/Neutral/Drive/Manual V's Battery Voltage
  These are by far the most critical, once you get these right, a lot of the other tables will work perfectly with them.
  Note: changes here often need the throttle to be blipped over 2500rpm to reset the stepper motor to use the new desired idle settings.

Most of the other tables rarely need adjusting but you can see there are a lot of different variables that can be altered to give the correct startup characteristics.
One thing to keep in mind with a lot of these settings, if putting a Delco onto another engine for example a Holden 202 motor, this engine might not have power steering or a/c so the IAC settings might need decreasing to account for less load that the engine has, similarly the 202 being a 3.3ltr engine has different air flow needs at idle due to being a smaller engine than a V6 or V8. It's often wise to compare 4, 6, 8 cylinder engine IAC settings and work out the best compromise for your specific combination.

It's also worth taking a look in the Scalars section as there are a lot of IAC settings in there which all affect transitions, e.g. if you put twin thermo fans on your engine you might find the normal fan on IAC step increase needs to be raised to account for the extra load 2 fans puts on the alternator and this is usually seen in a log as the rpms dropping when the fan cuts in.

If you spend enough time playing with these settings you can get fans or a/c to cut in/out with almost no change in idle rpms, it's not a 2 second job but it is very easy to get far improved results once you spend the time on it.