

# Intercooler Options and Evaluations: Cleaning, Coating and Two Options from Alta

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## Overview

Jeff Perrin at Alta Mini Performance asked me if I'd conduct an independent review of Altas new Flow Through Intercooler (IC) prototype. I agreed to do so. I have also expressed publicly that I didn't think the design would work, meaning that if I found benefit, it wouldn't be so that I could prove myself right.

The stock Mini Cooper S uses a top mount intercooler, with air fed via a small scoop mounted in the hood. The intercooler is of conventional design, with cooling air flowing through its shortest dimension. This geometry requires the air to make a 90 degree directional change in flow, and the exit is directed at the top of the intake, further restricting flow.



The prototype IC breaks with convention, and has the air flowing through one of the longer dimensions of the IC, but eliminates both the 90 degree cooling air directional change, along with the restriction at the exit of the intercooler.



Also included in the evaluation is Alta TMIC, currently sold via many retail channels (note that Jeff says that the turbulators density has evolved over the product lifetime. I used one with an external turbulators density of 11.4 fins per inch), a stock intercooler, coated with a thermal dispersant available from many sources (in this particular case, Cradin Industries ([www.cradin.com](http://www.cradin.com)) performed the coating), the coated IC is shown in the photo of the stock configuration above. Since I don't currently run with an Oil Catch Can (OCC), I also evaluated the effect of cleaning the oil coating off of a dirty IC, to assess the benefits of the OCC.

A total of 9 runs were used for evaluating the OCC and thermal dispersant, of which 6 were used for quantification.

16 runs were used for the mass flow, HP, TQ and 40-60 times used in evaluating the two Alta configurations when compared to the stock IC, of which 15 were used for quantification.

13 runs were used to try to measure the possible improvement over the stock Alta diverter that could be achieved by using the flow through scoop, and Al duct tape to seal possible air leaks, of which twelve runs were used for quantification.

10 more runs were used to check the effect of the 91 octane gas as compared to the 100 octane results.

## Testing Equipment

I used my 2002 Mini Cooper S as a test-bed. It is a mildly modified car, with just over 65k miles on the odometer.

15% Reduction Pulley
Hot Air Intake
60mm M7 Throttle Body
Denso IK22 Sparkplugs
Kingborne Plug Wires
Pilo Coil Pak
Self-Tuned By-Pass Valve
OBX Header
One-Ball Exhaust Mod
MTH Basic Tune

For test equipment, I used BiM-COM beta software (Ross-Tech, LLC [www.ross-tech.com](http://www.ross-tech.com)) to log engine parameters, a G-Tech Pro RR performance meter (Tesla Electronics, Inc. [www.gtechpro.com](http://www.gtechpro.com)) for horsepower and torque numbers, two digital thermometer from Edmund Scientific, and Andy Smith of Ross-Tech lent me a Dwyer Instruments, Inc. Magnehelic differential pressure gauge. The last items were used to measure IC thermal efficiency and pressure drop. I recorded audio using a Sony Handycam DCR-PC105, as not all measurement equipment was connected to my laptop for automatic data logging.

## Test Method

For the power runs where HP, Torque and IC thermal efficiency were measured, I used a freeway on-ramp in San Mateo, CA (Sand Hill Rd onto 280 North). I would stage, start all data logging equipment, and go. Since I wasn't doing 0-60 runs, I would start the car in first, but rapidly shift into 2<sup>nd</sup>, so that I could maximize the RPM range that the G-Tech would use for HP and torque calculations. This resulted in top speeds of just 70 mph. A bit faster than it's legal to drive on the street, but much less than track conditions.

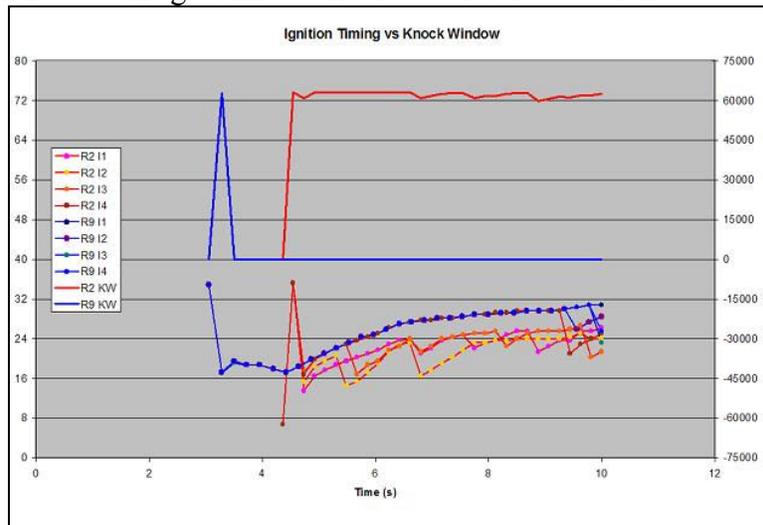
In order to condition the car so that all runs were roughly equivalent, after recording all the acceleration data, I would enter the freeway, set the cruise control for 70 MPH in 5<sup>th</sup> gear (to get an idea of IC pressure drop at about 3500 RPM under light load), and turn around at the next exit (Woodside Rd aka Highway 84). If any configurational changes were needed, I would perform them at a park and ride there, so I had the return trip to condition the car. For the return trip, I set the cruise control at 70 MPH in 6<sup>th</sup> gear.

For the pressure drop vs RPM, I did that at no load, revving the car and recording the steady state pressure drop as displayed on the Magnahelic. I couldn't capture this data dynamically to get the full IC efficiency vs RPM at full load.

I must also note that the flow through design used a special modified stock scoop with a much larger opening. So any benefits measured are a convolution of the IC design and the increased airflow of the scoop.

## Timing Retard

Initial testing showed that my Mini Cooper S with the above listed mods is always inducing timing retard using CA 91 octane gas. This meant that any results would be convoluted with timing issues introduced by the ECU knock sensor induced timing retard, and while this is the world that all CA drivers have to live in, it is not reflective of the quality of gasoline available to others. Because of this, some of the tests were performed with 100 octane gasoline available at a local 76 station.



The upper part of the graph shows the BiM-COM logged knock window energy, and the lower portion of the graph shows each cylinder timing for both the 91 and 100 octane graph. As you can see, the use of 100 octane eliminated any contribution to knock window energy. All data was time aligned to max fuel flow as determined by BiM-COM. While the car was certainly livelier with the 100 octane, the stuff is \$4.699 a gallon, and I just can't afford to run it all the time. It was fun while it lasted! It was interesting to me that cylinders two and three showed more timing retard than the others. Only one run is shown here to make the graph easier to read.

## Clean vs Dirty Stock Intercooler

My stock IC was pretty dirty. I have over 65k miles on the car, and while I do have an OCC in my garage, I have yet to install it into my car. After logging some data from the dirty IC, I poured acetone through the IC to remove the oil, and retested. It is possible that something like an ultrasonic bath would have cleaned the IC a bit better, as there was a bit of discoloration remaining after cleaning. But the photo below shows what I got out.



Cleaning the IC increased thermal efficiency about 1.4%, from 62.7% to 64.1%, but with a standard deviation of just under 2%, this difference is of dubious statistical significance. Peak HP improved 2.2 HP, but once again the standard deviation of the measurement was slightly over 4 HP, so once again, the difference is encouraging, but lacks statistical significance.

None the less, OCCs range in price from a few bucks (for items built out of Home Depot hardware) to well over \$100. For the benefits hinted at here, the lower cost OCCs can't really hurt, but very expensive ones are not justified due to the performance benefits they

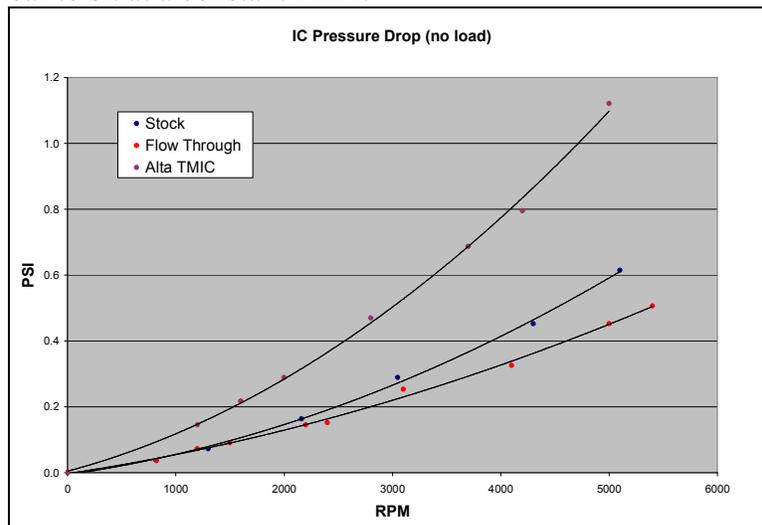
provide, unless aesthetics are thrown into the mix. But that is purely subjective, and defies quantitative measure.

## Thermal Dispersant Coating

One of the members on NAM posted some information about thermal dispersant coatings and the benefits they can bring. While the posted IC temps were just 4 degrees Centigrade cooler, this represents a 1% increase in intake charge density, and should be good for a bit less than 2 HP. Since the price is pretty reasonable (\$65 for an IC coating at Cradin), the cost per HP could be at the lower end of the performance mod scale. This got me curious, so with the help of John Milich (JLM of NAM), who provided two ICs, I sent them off to Cradin for coating. Here I have to point out that these ICs were far from new, and were a bit beat up. Even though they weren't "as new", they provided yet another 1.7% improvement in IC thermal efficiency, lowering IATs another 2.8 degrees centigrade. Once again, the results were more of a suggestion, and are about the magnitude of the measurement standard deviation. There was no HP or torque improvement noted, but the slightly less than 2 HP difference I was looking for was well under the measurement standard deviation. These tests were also run with the 91 octane gas, and all runs showed a similar amount of timing retard. These tests were also fairly early in my testing regimen, and the standard deviation of the tests reduced as I got better at the testing technique (due to better conditioning, and more data runs per state). To really measure if there is any difference in HP, I think an IC in better shape needs to be used, and more runs are needed to lower the standard deviation of the measurements (only two power runs were used for each state, with an additional conditioning run that wasn't used to set the car up, for a total of 9 runs for the dirty, clean and coated tests). And lastly, higher octane gas must be used.

## Intercooler Pressure Drop

For this test, I ran the car at no load, measuring the pressure differential across the IC as a function of RPM. Because the Mini uses a "drive by wire" throttle body, it's not exactly easy to get the car to sit at a constant RPM.



I did succeed in getting enough data points to fit a quadratic curve to the data for all three IC configurations (stock, standard Alta TMIC, and the Alta prototype), and you can see by the fit of the data, the error per data point is pretty small.

The data shows that the tested version of Alta TMIC has around a factor of two (2x at lower RPM, about 1.8x at 5000 RPM) pressure drop greater than the stock IC. Extrapolating these curves to a 7000 RPM redline, the stock IC drops 0.83 psi, the flow through 0.74 psi, and the standard TMIC a very large 2.1 psi. These number would be a bit greater at full load!

## Intercooler Thermal Efficiencies

The tests of the cleaning and the thermal conduction coating were done on a different day than the power runs for the stock clean IC and the two Alta variants. Because of this, they are not included in this table, but the results can be estimated with the results from the previous section.

Intercooler	Average Peak Mass	StDev	Best Number	Worst Number	Ave IC efficiency	StDev
Stock	714.1	11.7	728.0	695.75	64.2%	2.4%
ALTA TMIC	708.1	7.4	714.5	695.5	61.0%	2.6%
ALTA Flow Through	720.2	7.4	727.3	709.75	54.5%	2.2%

While the numbers for mass delivery (as determined by BiM-COM) and thermal efficiency numbers for both the stock and the standard Alta TMIC are identical within statistical significance, the new Alta prototype shows improvements in mass delivery when compared to the standard Alta TMIC that are statistically significant. This is despite the much degraded thermal efficiency of the design, a difference of 6.5% in overall thermal efficiency, that is also significant. In English, this means that the lack of cooling of the prototype is more than made up for its lack of backpressure. It is also interesting to note that the stock IC had the very highest mass delivery measured and within spitting distance of the worst, in fact equaling the worst mass delivery, unless you go out to digits that lack any significance at all! All of these numbers were determined with 100 octane gas. But as the cars use port injection, the thermal efficiency numbers shouldn't change for 91 octane either, as all this action is happening prior to the injectors.

I did try to improve the airflow of the standard TMIC, by limiting air loss going around the front of the IC (where there is a gap between the IC and the rear edge of the hood scoop, and sealing an approximate 1/16" inch gap at the back of the diverter (where it meets the rear edge of the IC) by using some Al duct tape, but another 13 runs determined that this only improved overall thermal efficiency 1%, leading me to believe that there is some leakage at the top of the diverter. Jeff Perrin of Alta Mini Performance has some new seals to try, but they were not used in any of the tests.

## Horsepower and Torque: 100 Octane

This is where it all comes together. HP and TQ. The G-Tech software has a nice feature where it will give you 40-60 mph times as well, so I included them in this table.

Intercooler	Average Peak HP	StDev	Average Peak Tq	StDev	Average 40-60 (s)	StDev
Stock	166.4	2.4	150.2	2.6	2.66	0.05
ALTA TMIC	166.8	2.8	151.8	3.6	2.65	0.05
ALTA Flow Through	171.9	3.9	153.4	2.2	2.61	0.04

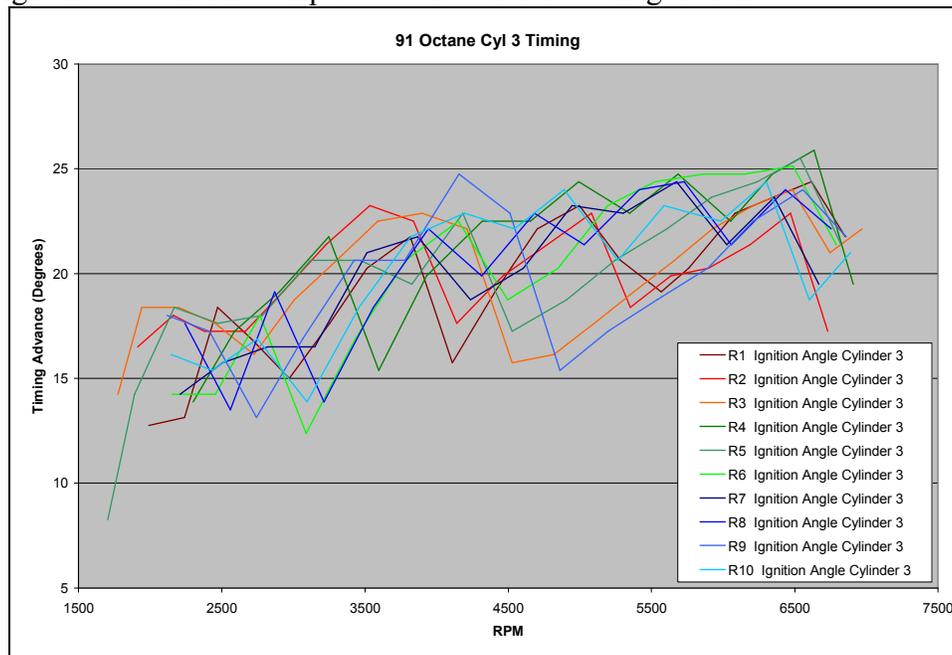
The stock and tested version of the Alta TMIC performed nearly identically. The Flow Through design did show peak HP improvements that are starting to have statistical significance, but just barely. It is interesting to note that there are only 5/100ths of a second difference in average 40-60 mph times, which is a number of no significance at all.

## Horsepower and Torque: 91 Octane

Since the Mini ECU retard timing rather significantly (others have shared data for a car with a 15% pulley not running MTH that shows timing retard as well), the tests were repeated with crappy CA 91 octane gas. These results are show below.

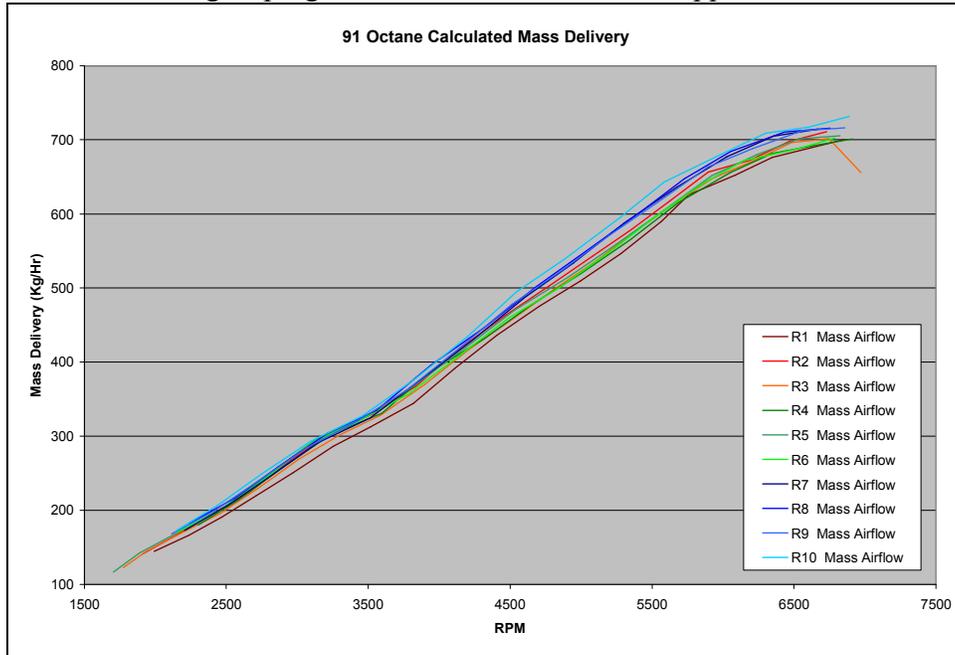
IC	Ave Peak HP	St Dev	Ave Peak Torque	St Dev	Ave 40-60	St Dev
Stock	158.8	1.7	149.4	2.4	2.74	0.04
Alta TMIC	159.7	1.2	149.4	0.7	2.76	0.01
Flow Through	161.4	2.3	151.3	2.3	2.70	0.04

The horsepower number deltas are somewhat less than with the 100 octane gas. So why is this? The timing and knock values give hints as to the source of the suppression of the improvement. If you look at the section above where the timing from one of the 100 octane runs is shown, you can see that the timing retard for all ICs is significant. If one looks to the knock window data as well, one sees that all the 91 octane runs for all the ICs exhibit similar results. But keep in mind that the flow through design delivers more fuel, and a slight increase in HP compared to the other IC configurations.



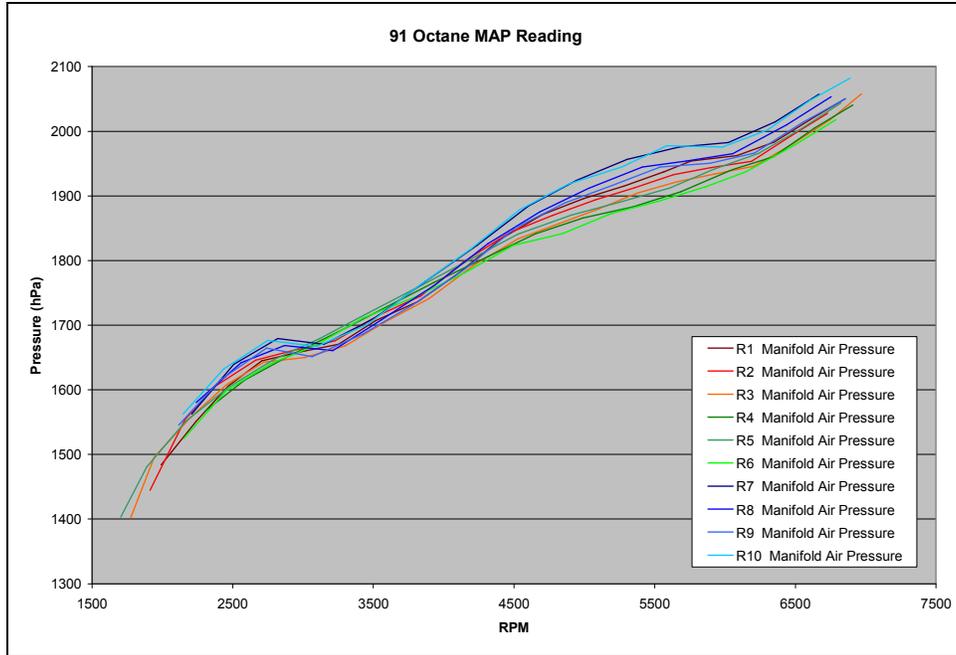
## Other 91 Octane Data

I logged other data via BiM-COM during the 91 octane runs. For all of the graphs shown in this section, runs 1-3 are shown in shades of red, and correspond to the stock IC. Runs 4-6 are shown in green, and correspond to the standard Alta TMIC. Runs 7-10 are shown in shades of blue, and correspond to the flow through prototype. The use of shades of color was done so that groupings and trends would be more apparent.

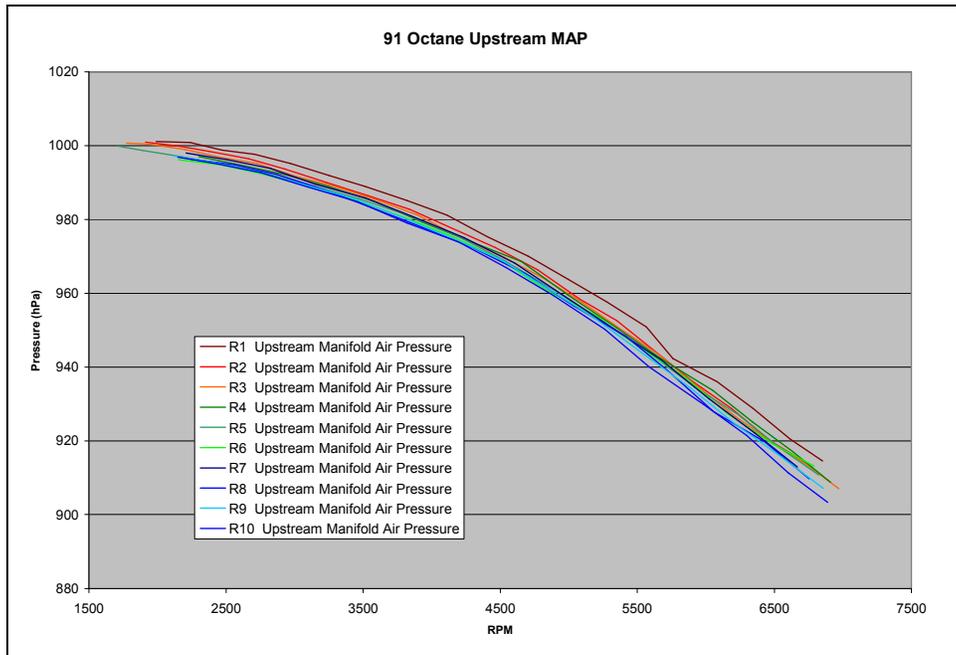


The mass deliver replicates the data shown before, with the new flow-through prototype having the most mass of fuel delivered by the ECU.

Some interesting effects were visible in the upstream (pre-SC) and manifold (post-IC) pressures. Besides seeing about a 10% decrease in upstream pressures due to flow restrictions in the front end of the intake track, some structure is visible in the post IC pressures. These structures are only most visible in the flow through prototype IC configuration, and almost undetectable in the standard Alta IC design. Because these differ in the amount of pressure drop, I can only guess that some sort of intake resonance effect is responsible.



For the 5300 RPM region, manifold pressures vary as much as 5% between all the runs. A slight grouping effect is visible in the pre-SC pressures, but it is only about 2% of the total pressure.



## Summary and Conclusions

- CA 91 Octane gas really sucks. For those of us that drive our cars in CA, we have to tolerate a decrease in performance, unless we shell out the big bucks for higher octane gas. Street drivers are pretty much stuck with it, but if you go to the track, or treat yourself to an occasional tank of high octane if it's available locally, the ECU can take advantage of the decreased knock tendencies and really deliver the performance that is designed into our motors from the factory.
- The stock IC is actually pretty good.
- Using an Oil Catch Can doesn't hurt anything, and may help a bit. But the references I've read that say you can lose up to 5% of your HP with a dirty IC just don't agree with the results I measured. Since the benefit is so marginal, I recommend that if you want one, for performance reasons, get one of the less expensive ones, or make your own. If you're buying for the looks of some of the more expensive units, know that you're paying for looks more than anything else.
- The thermal dispersant coatings are good for a few degrees centigrade reduction in intake air temps. Considering the cost of aftermarket ICs, I recommend that anyone who buys an aftermarket IC, or just wants to improve the stock IC, get it coated. Keep in mind that it's a spray on, so it won't penetrate very far into the flow through type designs. But don't expect lots of HP improvement over stock.
- The version of Alta TMIC that I tested needs work. It has too much back-pressure, and the diverter needs improvement. It leaks at the back of the IC, lets air around the front of the IC, and may not seal that well against the hood. To be fair, every aftermarket IC I've seen can use improvement in their diverter, and Alta is no exception.
- The new flow through prototype shows promise! I really didn't think it would, but it does. How much is the design, and how much is the scoop and front diverter isn't clear, but the whole package showed the best performance numbers of all tested in this evaluation.
- Get a scoop. Testing done earlier by TonyB and me with an M7 Extreme Scoop and his GRS intercooler showed that the scoop provided considerable benefit. Note that those measurements were with the diverter as delivered from GRS, and Tony has since improved it, but we never tested the improvements quantitatively.

## Other Comments and Speculation

My testing technique improved over the course of the evaluation. In retrospect, I should have logged more data for some of the 100 octane runs, and all of the coated and clean vs dirty runs. Because of this, I can't compare numbers across all of the tests. This was my mistake, and will be addressed if I do any evaluation at a later date.

What about all the posts and claims of a 10 HP improvement from the TMICs for sale in the marketplace? Well, I sure didn't see them. I can only speculate here, and without a direct test of a car that shows the benefit on the dyno, and then being run with accelerometer testing on the street, these guesses are only just that: guesses. I

think that the larger ICs may cool better with the hood open and a fan being run against them than the stocker, but really, this is just a WAG (wild-ass guess). I really don't have a clue why some measure large differences, and I saw little, if any.

Most of the testing was done at speeds that are more representative of street driving. There are two cases I'll discuss further: On the track, and very hot climates:

**On the track**, one drives at much higher average speeds, and much higher engine loads. In this case, you want every bit you can get. No matter what, get a scoop, and seal whatever air path there is to prevent leakage. The thermal dispersant coating is a good idea too. An oil catch can will help a bit with air charge temps, and under high average load, it will catch more oil than one just used for street driving. If you do choose to get an aftermarket IC, make sure to fix whatever deficiencies are inherent to the diverter provided, as many purchasers have done.

**If you live in a very hot climate**, coat your IC, and run a catch can. For just street driving, there are better ways to spend you money than an aftermarket IC, but if you've done all the easy modifications, don't let me talk you out of the purchase. But I, for one, don't put it near the top of the mod list, unless you can get one used, for a significant discount off of retail.

## Thanks and Acknowledgements...

First off, thanks to Jeff Perrin, who let me test his stuff.

Andy Smith of Ross-Tech, for letting me beta test BiM-COM, and lending me the differential pressure gauge.

John Milich for sending me the ICs for coating, and letting me keep the better looking one for testing.

My poor little Mini, that tool 47 full-power HP runs for the team, so we could see what there is to see.