

To K&N Or Not To K&N?

The use of K&N air filters in TDIs is a long-standing topic of contention here on the TDI forum, with the most visible contingent of posters being vehemently anti-K&N. Unfortunately, much (but certainly not all) of the information cited to support viewpoints is secondhand, incomplete, or based on studies that are not pertinent to TDI's or real-world applications. Sometimes the vitriol gets out of hand, and posters will go so far as to deliberately take information grossly out of context to support what is, IMO, irrational "K&N bashing". This (lengthy) post is an attempt to collect as much existing, meaningful K&N-vs.-paper-filter data as possible while also adding new, TDI-specific data using VAG-com and my 2002 Jetta TDI.

I have tried to remain neutral at all times in my presentation, allowing data and facts to speak for themselves. When I feel commentary is warranted, I have tried to present both sides of an argument and to make a reasoned judgment as to what the data says about both sides. This is meant only as a guide to readers who are less technically inclined, not a spin campaign to support any personal biases. I freely admit there are phenomena here I do not fully understand, and all are invited to try to shoot holes in anything I say or make clarifications where I have missed something-- HOWEVER, I ask that before doing so you go over everything presented here carefully so that we can all avoid pages and pages of wasted bandwidth with questions and points that are addressed in the OP.

My background/biases on the subject

I have owned at least a dozen cars in the past 22 years or so. My 2002 Jetta TDI is the first Diesel, and only the second to have a turbo. I have used K&N air filters in 5 or 6 of the gassers I've owned. In every case I have realized mpg improvements as high as 8% as well as obvious improvements in throttle response. Every case, that is, except one--significantly, it was a Volvo 740 turbo wagon. The filter didn't seem to change anything about that car. The only reason I use these filters is to improve mileage, and I always drive conservatively as part of that goal. Those who drive hard will often find high-flow air filters may enhance performance, but those kinds of drivers also often experience LOSSES in mpg--efficiency and performance being two sides of the same coin, as it were.

When I got the TDI, I wanted hyper-efficiency, so one of the first things I did was to drop a K&N into the airbox. I was scolded and lectured ad nauseum on the forum when I mentioned this in passing. After becoming dissatisfied with the reasons I kept getting (as I will explain), I decided it was time to do something on my own to see what was really going on in my coolest car yet. At this point, I would like to thank DieselOx who first suggested using VAG-com to take live measurements to test the veracity of certain arguments made. His suggestion spawned this entire project.

The bottom line

If you scroll down, you'll see how lengthy this post is. If you don't want to read the whole thing, it can be boiled down to this:

I no longer use a K&N air filter in my TDI. There is no mpg improvement to be had, and the performance gains are meaningless to all but those who race their TDIs competitively. Even racers will not see the full benefit of the filter without additional mods. There is also a certain amount of elevated risk of damage to certain engine components--mainly the Mass Air Flow sensor (MAF) and (less so) the turbo--when using a K&N, though IMO, the risks are often overblown by the bashers among us.

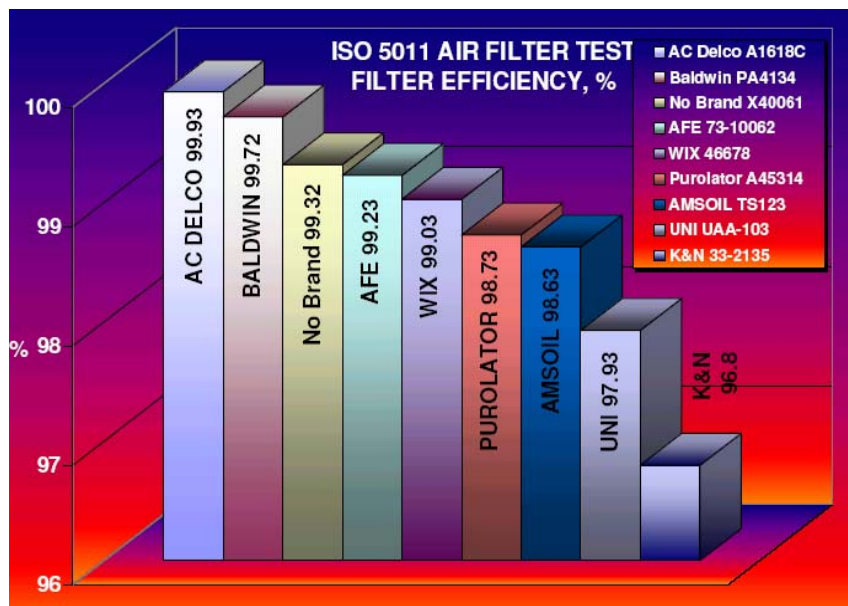
What's already out there

A number of relevant studies have been available on the web for some time now, and most of the best ones have been linked on the forum before by me and others. There are two primary parameters to consider when choosing an air filter—flow (or restriction), and filtration (or filter efficiency).

Here is the best-controlled independent test to address this issue that I have seen, and was performed with high-end laboratory test equipment:

<http://home.stny.rr.com/jbplock/ISO5011/SPICER.htm>

This study does a good job of quantifying actual and relative filter efficiency and flow characteristics of a number of air filters. Do note however, that the charts showing some of the data are scaled in such a way as to be potentially misleading at first glance. For example:



There is no question that the K&N filter was the least efficient filter of the bunch. However, the spread across all of the filters is only a difference of 3.13% in efficiency. We're only looking at the top 4% out of 100%. I don't feel the authors here were trying to spin the facts, but it does happen. Always read data carefully. Bottom line of this test—K&N flowed the best (if properly maintained), but also filtered the worst.

Good as this test is, I feel it does have one serious flaw when trying to predict real world filter efficiency. The test apparatus is not precisely described, but one assumes for this test they feed the test dust (that should be “coarse”, not “course”, BTW), straight through the filter, head-on. Even if they didn't, every model of vehicle has different flow characteristics through the airbox. See the link below, where a study by the physics department at Oklahoma State University found that filtering and flow efficiencies were clearly affected by turbulence ahead of and behind the filter.

<http://adsabs.harvard.edu/abs/1996APS..DFD..EG04C>

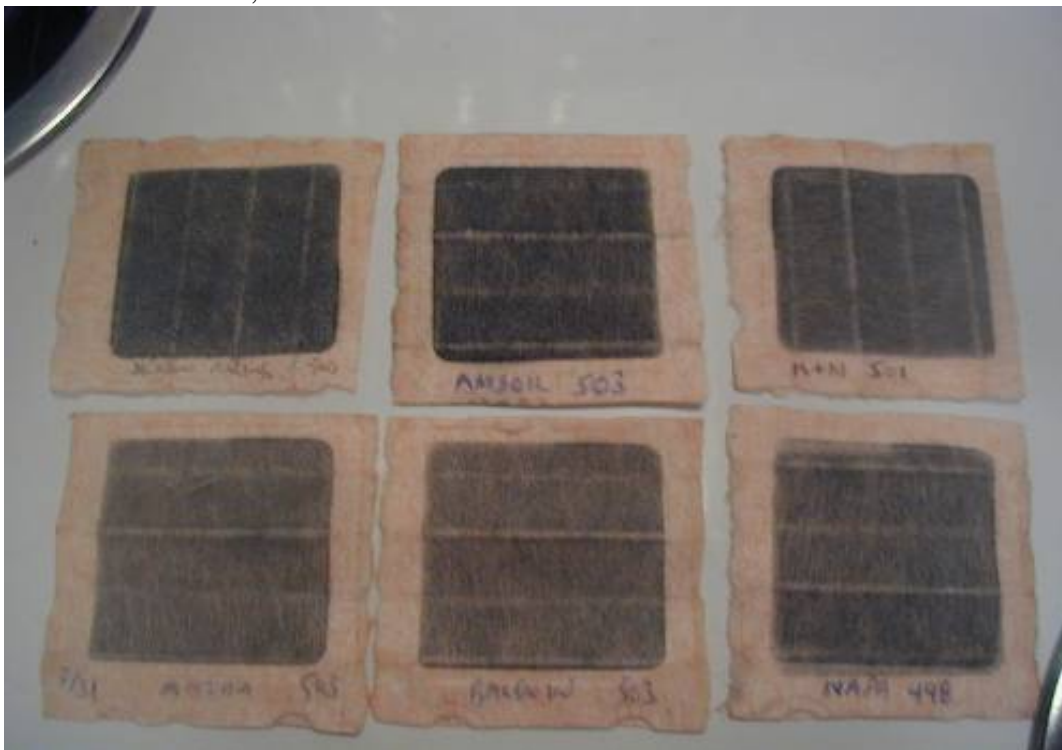
The biggest problem with this link is, of course, that the experiment is not described in detail, and the data not given. However, it should be obvious that eddy currents and variations in flow concentration will have effects over the life of the filter that are impossible to predict in a universal test setup. Actual filter efficiencies may be better or worse in your particular vehicle than the first link says they will be. Anyone who doubts this should take a look at this photo, which shows the dirty side of a new K&N after about 5,000 miles in my Jetta.

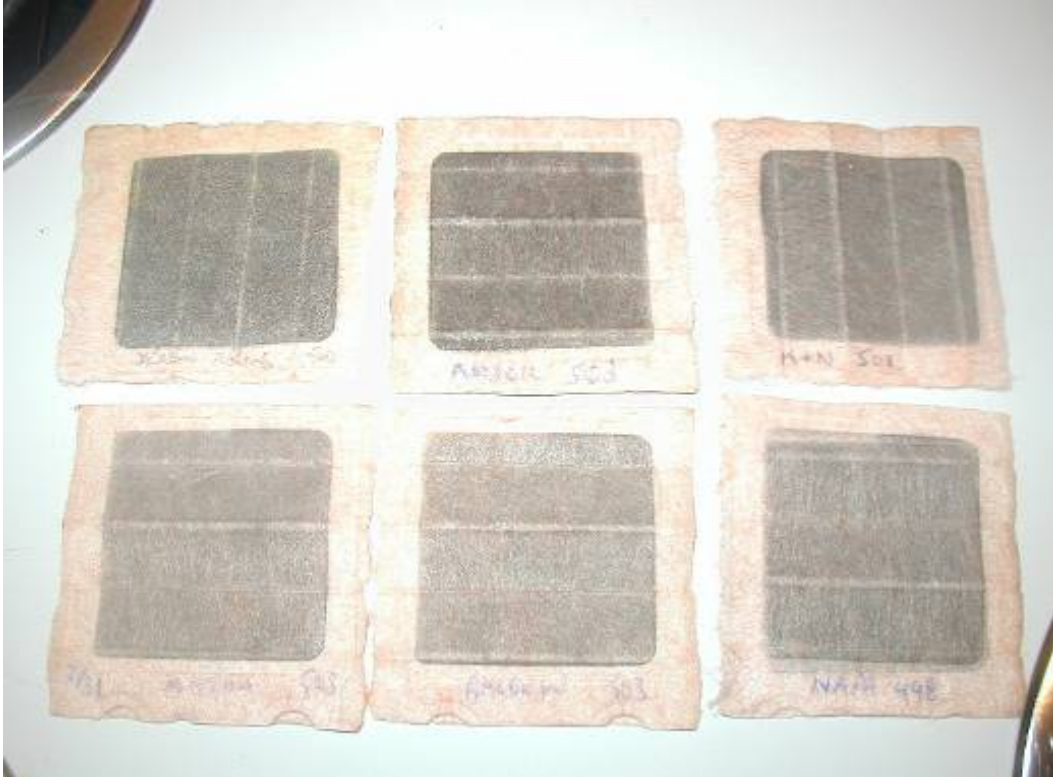


There are clear biases in flow at work here; less than half of the filter's surface has visible signs of having passed air. As those portions of the filter begin to clog, others may favor flow more than before. Finding actual filtration results is well beyond the scope of this write-up, but the phenomenon does exist and should not be dismissed out of hand. The next study brings this point home when compared with some results in the first link.

<http://www.bobistheoilguy.com/airfilter/airtest1.htm>

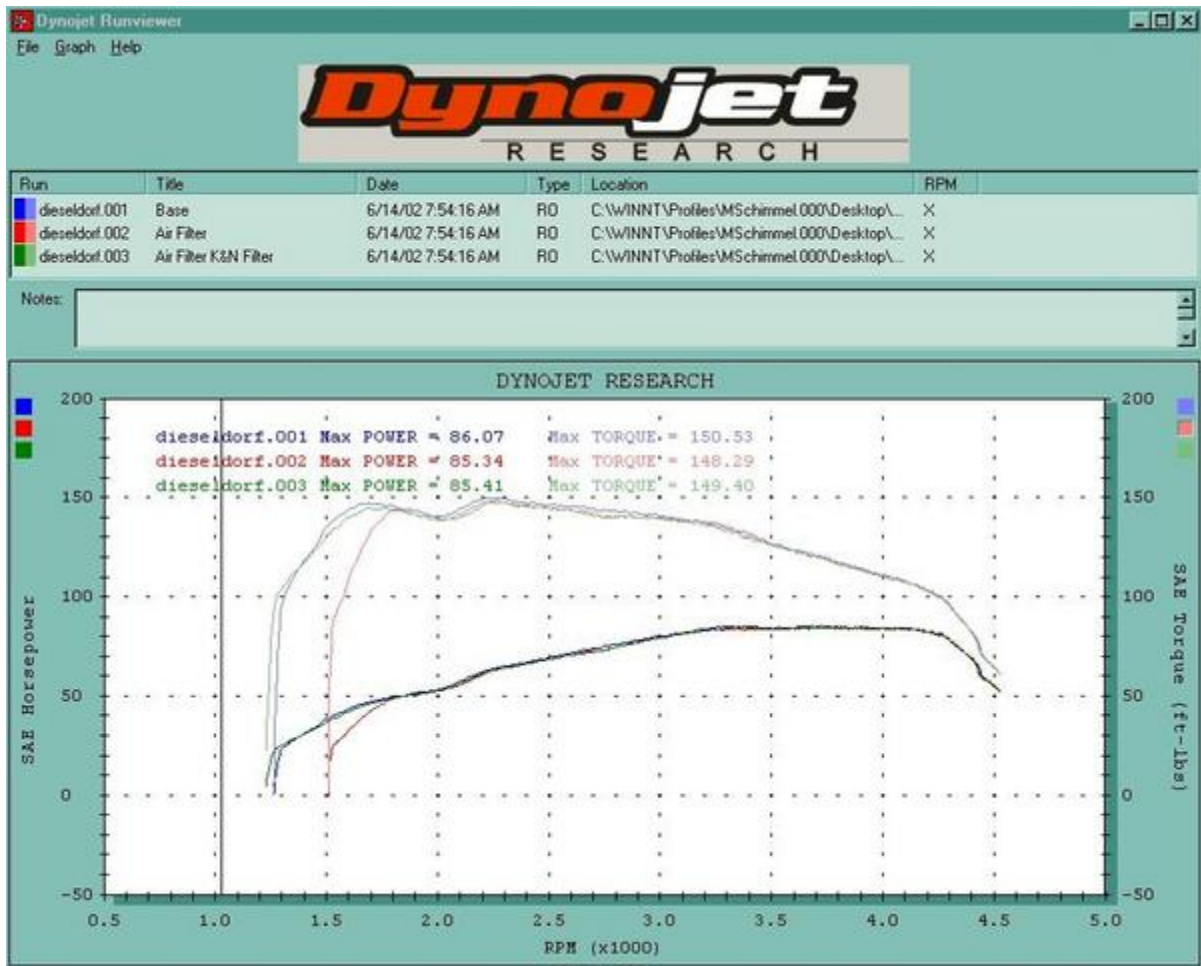
This test was performed in a Mazda Miata. A bit of Fram filter was put behind a variety of other filters to give a visual representation of relative filter efficiency over the course of 500 miles of actual everyday driving. The tester also used a manometer to find flow characteristics. The photos below probably look somewhat familiar because another photo from the same study has been posted here repeatedly—a picture that shows only the K&N results. Remember what I said about spinning the facts? What you probably haven't seen posted around here is the total of all of the filters tested with the obvious result that the Amsoil filter was much worse than the K&N (not what the first study found) and that the K&N appears to be not much worse than even the stock Miata filter at the lower left. In fact, the K&N (upper right) is almost indistinguishable from the NAPA Gold paper filter just below it. The first linked study found the K&N passed 18 times more dirt than the Delco filter. Do the test results here show similar results? It bears repeating-- real-world filtration results are VERY difficult to predict. The top photo was taken without flash; the second was taken with flash.





The bottom line of this test was K&N flowed best, and filtered second or third worst. The tester also found oil-shedding to NOT be an issue with any of the filters, a problem that is often cited on this forum as leading to the destruction of MAFs. (I also did not find any evidence of oil contamination on my MAF, which will be discussed later.) The greatest problem with this test is probably the lack of control over weather and road conditions. The results could be skewed because of this.

Finally, we have seen dynamometer tests showing very little to no power gain with K&N over stock paper filters. This comes courtesy of Dieseldorf:



While max power and torque are not meaningfully affected, the very bottom end of the powerband does show considerable improvement with the K&N (I'm sure DD will correct me if I've misinterpreted something here.) So while there isn't a power increase per se, there is a performance enhancement. This may be due to the delay in the turbo's response being mitigated by the freer flowing filter. More on this later.

So to recap.....

Conventional wisdom here has it that:

- 1) The turbo can pull more than enough air through a stock paper filter to get full power from the TDI engine. Thus, there is no meaningful performance gain to be had with a K&N in a TDI (some say no gain at all). This should also mean mileage will not be affected by a K&N.
- 2) Additional particulate matter passed by the K&N is hazardous to the health of your MAF and possibly your turbo and engine innards.
- 3) K&N filters shed their oil, which will also destroy a MAF (this opinion is less universally held.)

But as we all know, conventional wisdom can be wrong. Fortunately, most of these claims can be tested and verified with a little initiative, a camera, and a VAG-com.

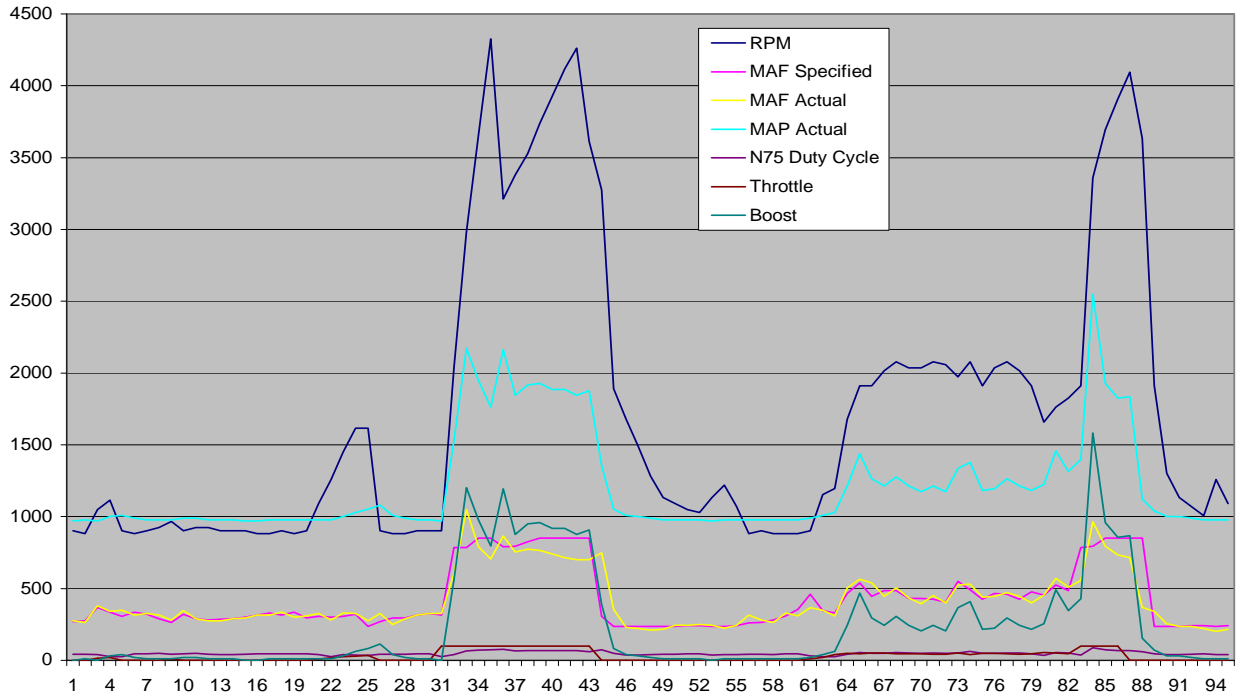
The results of my own tests

I wanted to test several things. First and foremost, is there any difference in mpg with the K&N? Is there really no difference at all in performance with the K&N? Will the K&N really coat my MAF with oil and dirt?

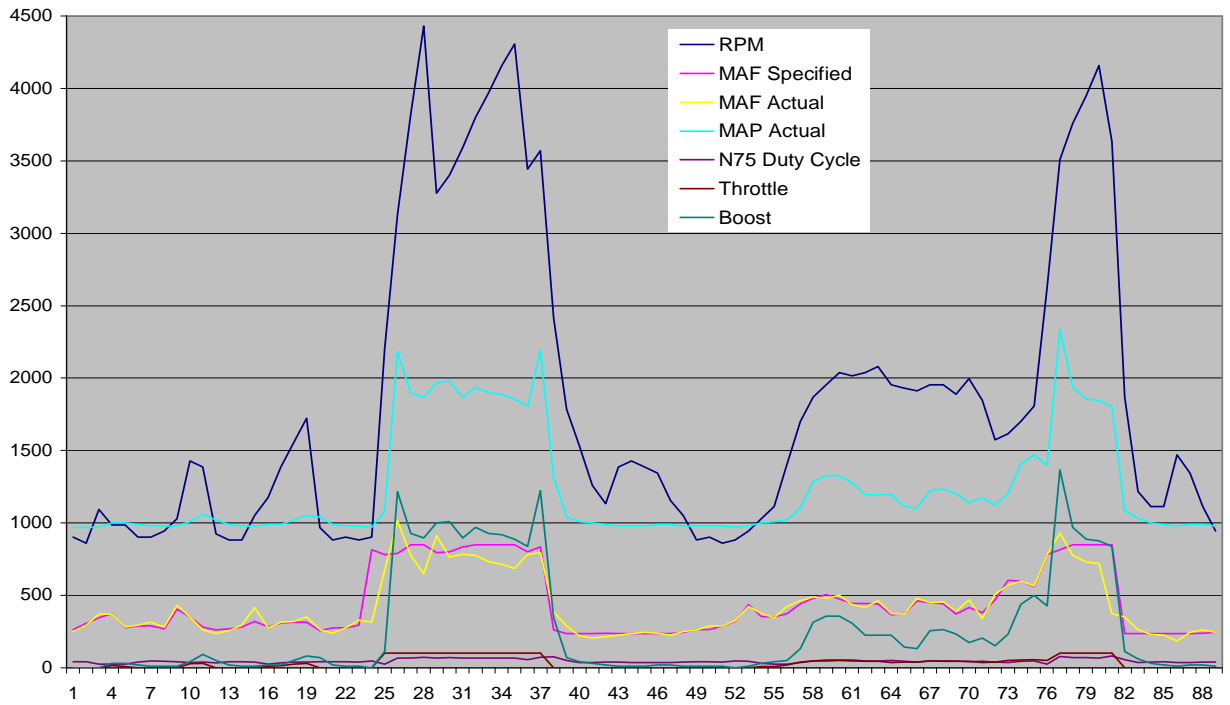
I made no attempt to quantify differences in filtration efficiency, mainly because I think it is a given that K&N filters do not filter as well as paper. However, that alone does not mean that your engine will necessarily suffer significant harm because of this. Anyone interested in proving this would need to do used oil analysis with 10,000 miles (just to pick the standard OCI) with a K&N and 10,000 miles with a paper filter, ideally under as similar driving conditions as possible. Somewhat higher silicon levels are just about guaranteed with the K&N, but this alone does not indicate engine wear. One would have to look for elevated levels of wear metals in the oil to prove actual engine wear. Perhaps somebody who is more pro-K&N than I am would be willing to do this. I may try it in a gasser at some point, but I will not be doing this in my TDI, mainly because I want to get on with my WVO conversion. To check the rest, here is what I did:

I used two different filters--the K&N with about 5,000 miles on it and a brand new Mann paper filter, the one specified for the Jetta (not cold climate). I found an industrial park on a dead end street about 1/2 mile long and drove it the same way twice within about ten minutes, once with each filter. After getting to the starting position, I gave the car WOT (Wide Open Throttle) from a dead stop until reaching a pre-determined point on the road after which I coasted and braked to the end of the road and turned around. On the way back, I aimed to keep rpm's around 2000 (the car has an automatic trans) until a predetermined spot was reached at which point it was back to WOT as long as safely possible, then I coasted and braked back to a parking lot. My repeatability was not perfect, but it was pretty darn good. Using VAG-com, I measured rpm, MAF actual, MAF specified, MAP actual, ambient atmospheric pressure, throttle, N75 cuty cycle (this controls the turbo's boost level) and some other parameters that were in the same blocks, but not relevant to the test. Boost level was calculated by subtracting atmospheric pressure from MAP actual. Here are the graphs for each run with all relevant data available:

K&N Filter



Mann Filter

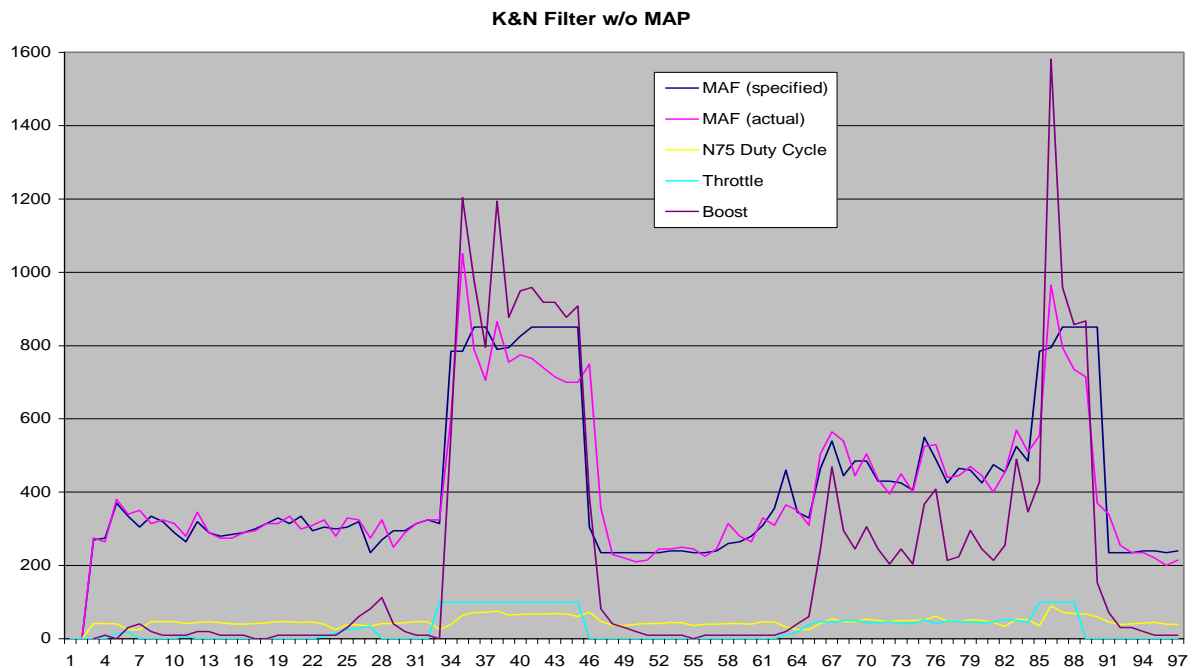


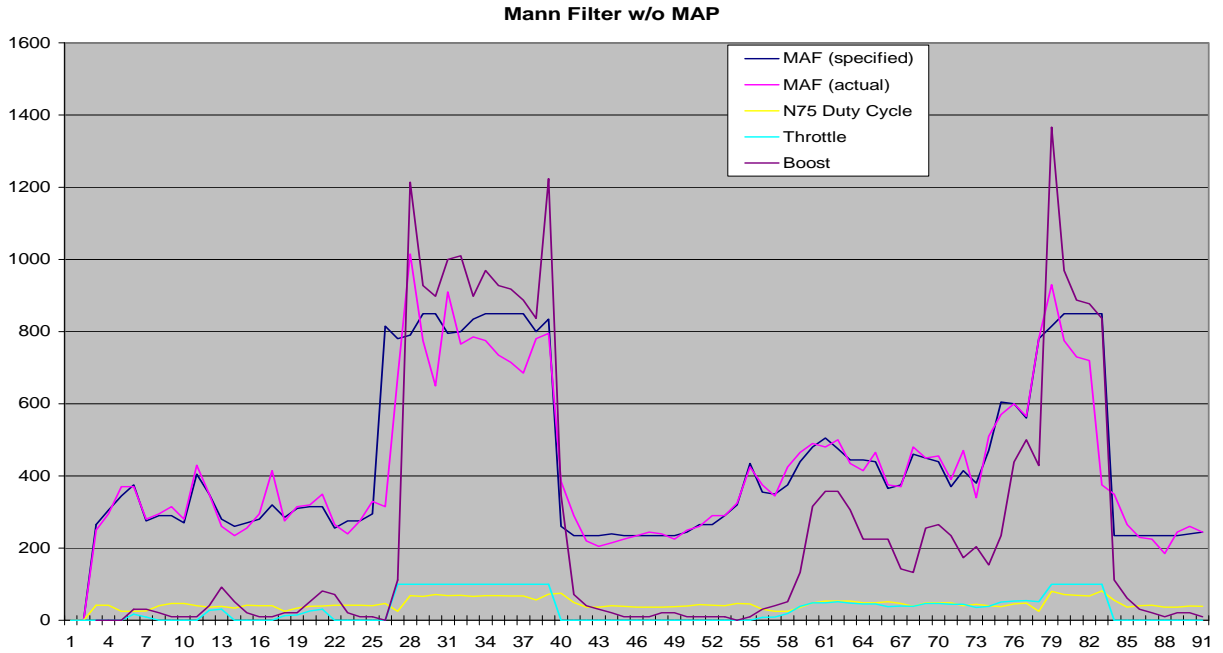
I want to point out right away, that the resolution of the data is not as good as I would like. When measuring 3 data blocks, the sampling rate is only about 1 round of samples per 0.9 seconds. Thus, each tick mark on the X axis in these charts thus represents about

0.9 seconds of time. Even with the low sampling rate, the results are quite consistent with themselves and with other measurements I had taken previously under less controlled conditions. I am confident in the veracity of these measurements.

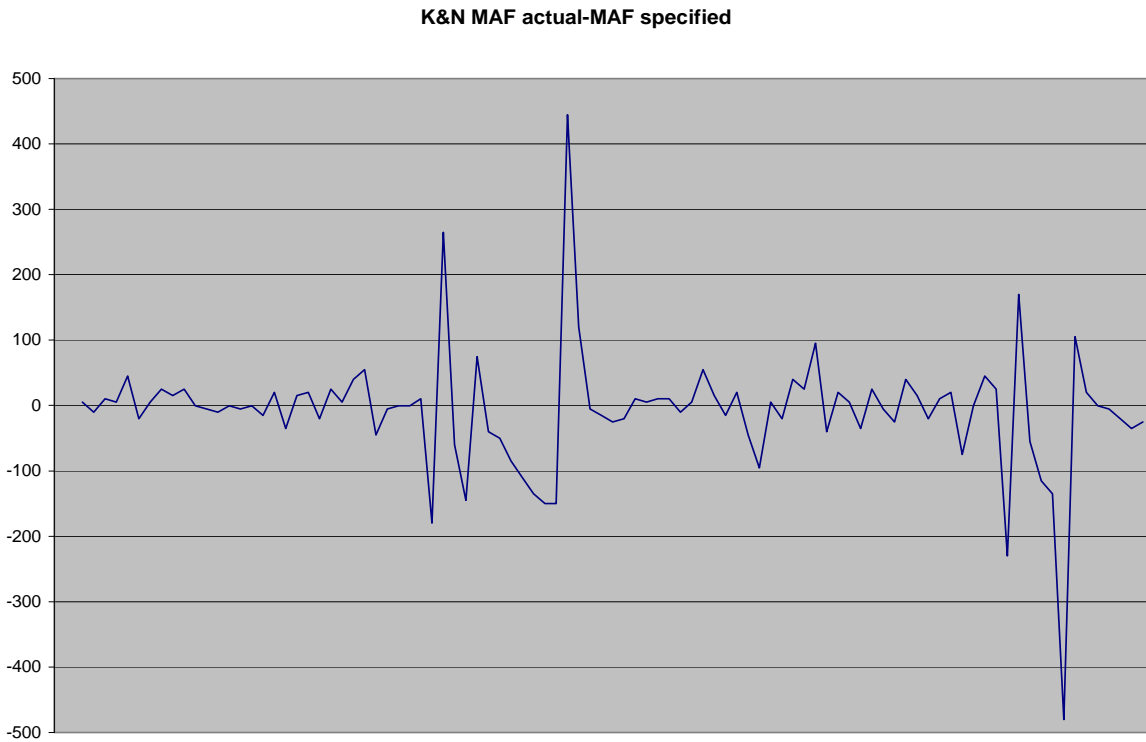
Some here have claimed a Mann filter will outflow a K&N because of its larger surface area. This data unambiguously shows the K&N easily outflowing the Mann filter. The K&N had higher MAP levels with less work from the turbo and MAP tracked rpm MUCH more closely with the K&N, especially on the second acceleration burst—in other words, boost pressure builds faster with the K&N. This did result in a small but measurable performance gain I will show in more detail down the page. Interestingly, the Mann resulted in slightly higher rpm than the K&N, and I find myself wishing I could have also measured load and IQ. Also puzzling is that, although boost levels built more than a second faster with the K&N with WOT from a dead stop, there was virtually no difference in acceleration in the first burst between the two filters. I can only figure this is due to the "tuning" of the stock ECU. It would seem that to realize the full benefit of the faster boost response, one would need to rechip the engine with a chip made to take advantage of it. Bigger injector nozzles may help as well. Whatever the reason, this is NOT because the turbo completely overcomes the additional restriction of the Mann filter, as was predicted by some before this test was conducted.

To make the low level data easier to see, I'll show the same data without rpm or MAP actual. This makes the difference in N75 duty cycle much easier to see. Again, note the marked delay in boost with the Mann filter, which is easiest to see in how MAF actual and boost trail MAF specified:

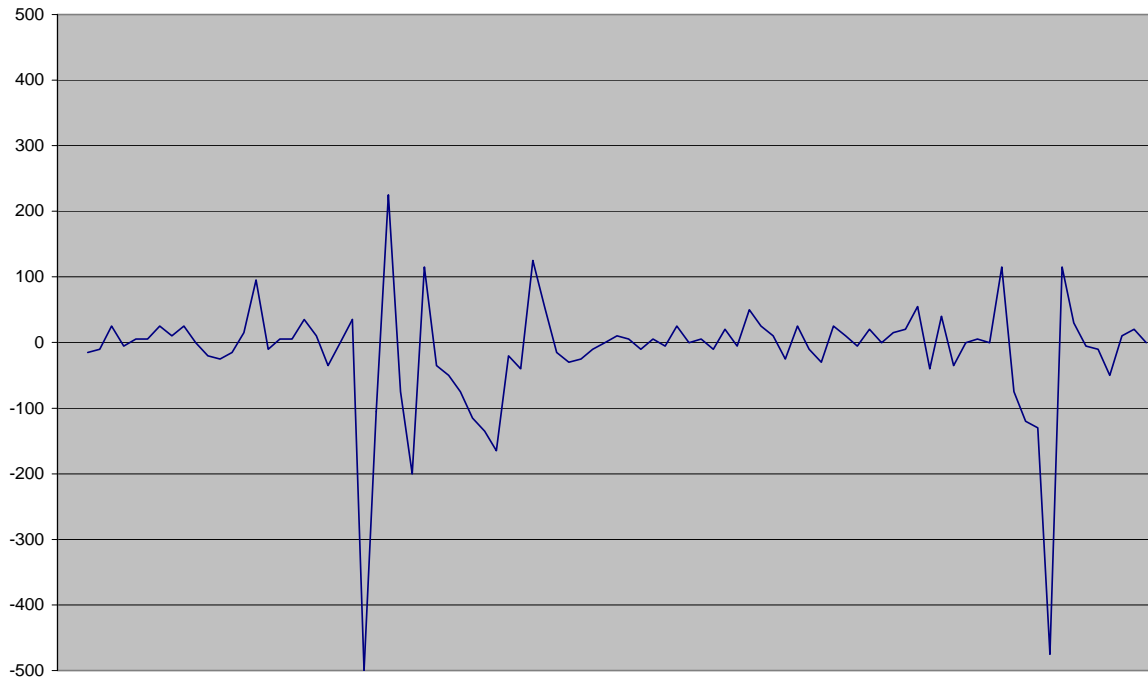




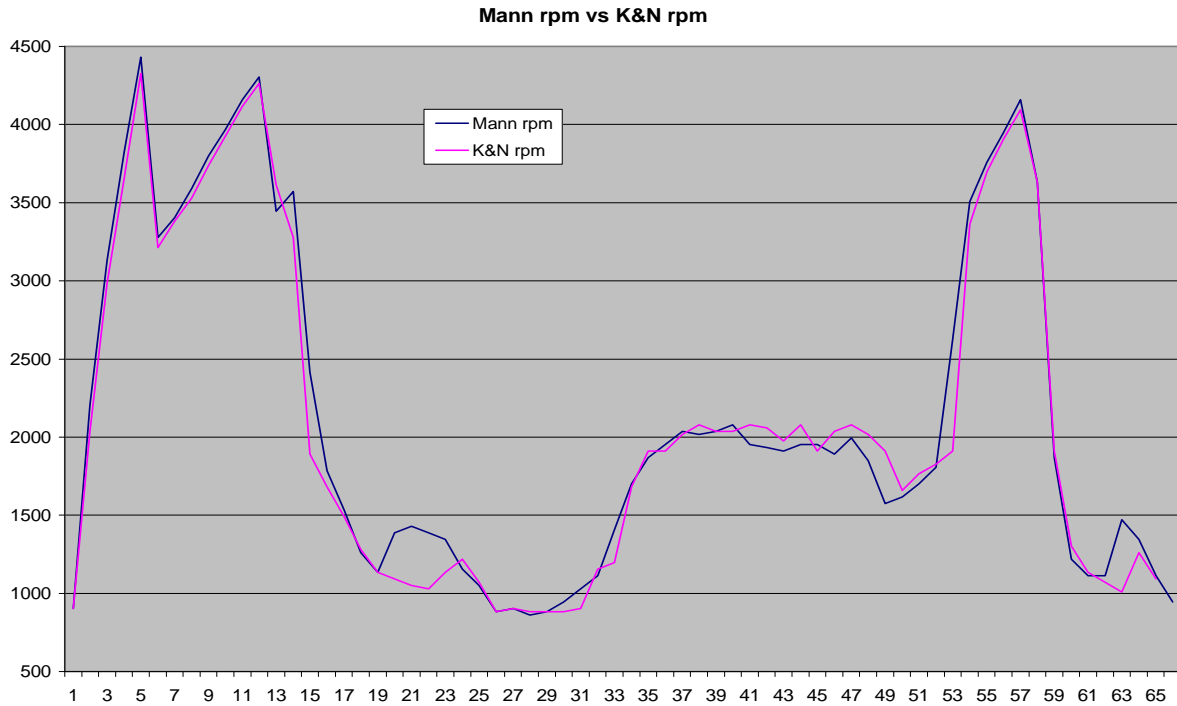
This next charts show the difference between MAF actual and MAF specified for each filter. Data above zero shows the filter flowing more than MAF specified; below zero the filter is flowing less than MAF specified. This drives home the fairly dramatic difference in flow between the two filters:



Mann MAF actual-MAF specified



OK, so far we can see that the K&N flows better, but any actual performance difference is difficult to discern. Here is the rpm for each run shown on the same graph. From a dead stop there is virtually zero difference. When accelerating while already moving however, the K&N does appear to have a slight edge with faster acceleration:



I pride myself in attention to detail but honestly, if I couldn't see it on the chart I would have said the performance was identical between the two. This is in sharp contrast to my gasser experiences where I've suddenly found I have to be much lighter on the pedal to avoid rear-ending the guy in front of me when a light turns green. I think it's fair to say that between the turbo's forced induction and (probably more so) the ECU's tuning, whatever advantages the K&N has in flow are almost completely wiped out in an otherwise stock TDI.

So what about mileage?

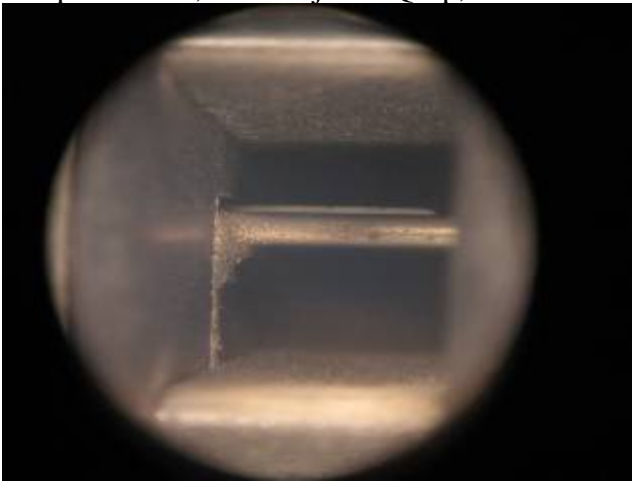
Here is the mpg for my last 4 tanks of gas--3.5 tanks actually, from least to most recent:

- K&N-39.5
- Mann (1/2 tank)-38.4
- K&N-39.6
- Mann-39.5

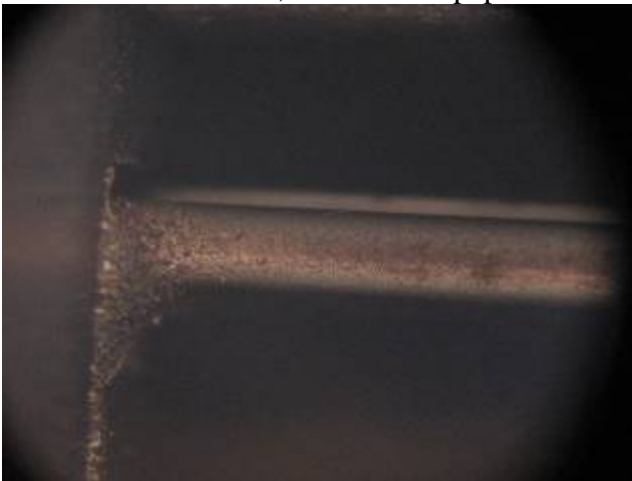
Mpg generally has hovered around 39.0 +/- .5 since we started getting winterized Diesel here, regardless of what filter I use. In the warm months, I was getting 41.25 +/- .5 with the K&N always in. The numbers speak for themselves. There goes my only reason for using a K&N in the first place in this car.

How about the MAF?

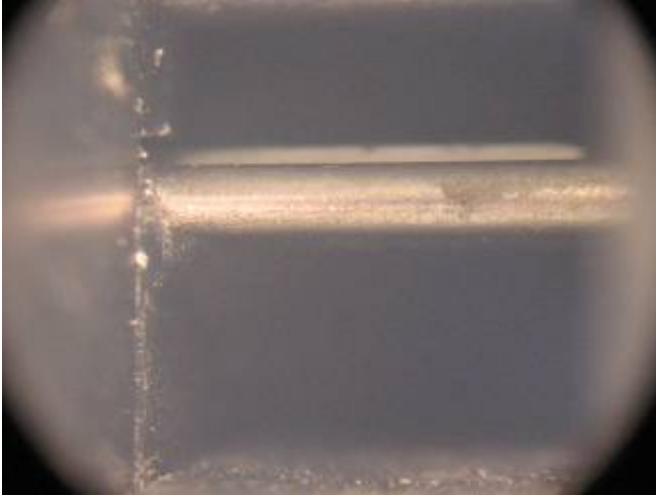
The MAF appears to be the factory original based on the date code molded into the ABS body. The first time I looked at my MAF and cleaned it, I was looking at the wrong spot. Intuition would tell you the larger opening is the business part of the sensor, but it's not. After seeing photos of the heated film element, I realized that the smaller opening is where the sensitive film sensor is. Therefore, the first time around I was not looking in the right place for debris. Unfortunately, this means I don't know how much dirt was there when I first started running the K&N vs. the amount seen in the photos here, taken after 5,000 miles with the K&N. That's the bad news. The good news is that there has been no trace of filter oil on the MAF either time I've looked at it, and the dirt buildup on the leading edge of the sensor is easy to clean off with contact cleaner, compressed air, or even just a Q-tip, like I did here.



Dirt on MAF after 69,000 miles of paper filters and 5,000 miles with K&N.



A closer look at the dirt.



MAF with the dirt cleaned off. Note the blob of adhesive (or some other manufacturing artifact) that was making the dirt accumulation appear larger than it actually was.



All removed debris on the end of a Q-tip.

The MAF in the TDI is notoriously delicate and prone to failure, even with stock filtration. Only a fool would suggest that K&N's don't pass more debris than most paper filters; the evidence is overwhelming. The general consensus here is the less particulate exposure to the MAF the better, and that's a reasonable position. However, I think it's also reasonable to say that a little due diligence in the form of regular cleaning can greatly mitigate the risk of damage to the MAF. As far as oil goes, I've seen pictures posted here of MAFs caked with it. The only way I can reconcile this with my own experience is to assume that the filter was grossly over-oiled in those cases. Maintaining a K&N filter has to be done properly, and it's not for everyone. However, at this point, in this vehicle, one has to ask--What is the point in even trying? For the everyday driver, there is virtually nothing to gain, even if the filter lasts the life of the car.

Closing remarks

As I've said before, I will continue to use K&N filters in my non-turbo gas vehicles because of the easily observable mileage gains I've repeatedly achieved. In turbo vehicles, these gains appear to be greatly mitigated, especially if the ECU is tuned in such a way as to render the engine incapable of taking advantage of filters that flow more freely than stock. It seems reasonable to conclude this is the case with the ALH TDI. If you're after mileage gains, the K&N won't help you in a TDI. If you're after performance, a K&N will make a difference, but only a very small one without additional (and very careful) modification. More study would be required to say anything more specific than that. Anyone using a K&N in a TDI for any reason should probably add regular MAF cleaning to the maintenance schedule.

I hope some of you have found this interesting, entertaining, educational.....pick your favorite adjective. As was suggested in another thread earlier, I do plan to try a portion of the K&N in front of the Mann as a sort of "prefilter" as a means of getting even better air filtration. I'll post on that when it happens. Until then....happy spooling!