1987 VW 16 VALVE TURBOCHARGER
THE DYNO APPROACH

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After the initial design considerations were made in the engineering department the finished product was handed to the dyno room for evaluation of the basic system and to hopefully uncover any problem areas which may be present before the kit makes its way into the vehicle and ultimately to the consumer. The basic VW package has proven extremely reliable over the years so there were no fears of reliability or durability problem with the VW generated pieces. Before the turbo kit was installed on the dyno engine a thorough break in and evaluation was made of the delivered piece from Volkswagen. From the very beginning there was a problem with the fuel delivery system even though the fuel system setup was based on the Volkswagen instructions in the manual.

The fuel system was flow tested in its standard condition in order to find whether or not it could supply the modified engine with the fuel for the increased power levels. This was measured, and it was found that there was adequate fuel for 225 horsepower. A potentiometer was hooked in series on the temperature-sensing unit for the fuel injection thermal sensor. We had envisioned enrichening the mixture with that rather than a microfueler system. We found that this method was improper because of a control problem from non-boost to a boost condition. The particular potentiometer used was so sensitive to position that it could not be used.

The fuel system was not receiving a full throttle signal from the ECM. This would manifest itself as a dip in the fuel supply to the engine at approximately 5000 RPMS which would probably cause the engine to go into the default mode of fuel delivery and ignition timing. Our information was inadequate in order to eliminate this until later in the development process. We could make the engine run and develop in excess of 200 horsepower, however, the fuel curve was definitely not proper and air fuel ratios were lean until changes were made. It was also found that the idle circuit was not being engaged. What this does is give a reference point for the ECM to base all of its information on. The combination of these two factors led to the ultimate fuel problem, which we encountered. Testing had proceeded considerably until a final solution to the problem was obtained from {Superflow Dyno) required the installation of a couple of jumper wires on the dyno wiring harness in order to send the proper signals and finally end the problem with our fuel curve. This turned out to be the major stumbling block of the entire test series and reinforces the need of the outside vendor and the manufacturer to interface better when dealing with the sophisticated new electronic systems now employed in the automobiles.

The oil drain system now used had to be tested. Even though we felt that there would be no problem each and every piece of the new kit required thorough testing to properly understand its performance and reliability. As in every developmental project some flaws were found and ultimately corrected. This oil drain system from the turbo suffered from an initial poor design which allowed pressure from the Volkswagen system to be directed up the return line thereby restricting oil flow from the turbo and ultimately creating problems with the lubrication of this piece. A new drain back device was fitted which diverted the drain back oil supply from the central portion of the return fitting by means of a cross-drilled orifice ending the potential problem.

The turbo employed in the test vehicle was a prototype manufactured by Rotomaster. The A/R of the turbine housing was .63 initially. There is an exhaust pressure map to quantify this performance, which is located in the graph area of this report. The only problem found with this unit was improper fitting of the integral waste gate control arm in its bushing. We have found problems with things of this sort in many of our prototype pieces. In production better materials are used which should end any problem in this area. Although the performance of the engine was spectacular it is felt that the response of this particular turbo is slower than we have come to accept. We will be conducting further research in the future to ascertain whether or not other suppliers can provide us with a unit with better response time.

The initial 2 to 2 1/4 inch intercooler cross section had two problems. The first was an excessive pressure drop across the intercooler, and the second was the initial design of the intercooler core and its mounting to the end tanks. Cracks developed at the junction of the core and the end tanks. These two problems were solved with a switch to a 3 inch intercooler core. When going to the new design of intercooler a change was also made to clean up the internal casting passages slightly to afford better airflow and hopefully reduce, even further, the pressure drop across the intercooler. These changes seemed to work successfully.

The evaluation of the intercooler was based on pressure measuring points located on either side of the installed intercooler. The first was made in the plenum area before the charge had entered the intercooler. The pressure probe on the exit side of the intercooler was made in two locations. At first measurements were taken in the injector rail cooling tube, which was found, after testing, to add a psi to the pressure drop reading. Readings were then taken from the number three runner to get a more valid picture as to the drop solely from the intercooler. Intercooler differential temperatures were monitored and found to be as high as 125-130° F. in the dyno application. Compressor discharge temperature had been as high as 232° F. We have found that the in car differential is even higher than we have found on the dyno.

A test was made to try different spark plugs. This experiment alone probably led to the early demise of engine number one. A cross reference was made to a Champion plug because it was found that no colder Bosch plugs were currently available. Although the straight reference listed the selected spark plug as being colder, it was in fact a slightly warmer plug, which led the engine into severe pre-ignition. This and the combining detonation which followed in future runs deteriorated the cylinder leakage in a couple of cylinders to a point (45% leakage) where we felt that additional testing was not gathering useable data. When testing resumed with engine number two some prototype spark plugs obtained from (Bosch) were used. They were considerably colder, in the 300 range, and performed superbly for the duration of the tests. Possibly the lack of full throttle enrichment signal from the electronics also contributed to this failure.

It should be noted here also that during the running of this test period at the Callaway facility the dyno department was switching to a more sophisticated dyno assembly. Progress of the engine development was slower than normal due to the initial setup of the new equipment as well as the sorting out of the many bugs, which are always involved with a change of this magnitude.

When all of the major problems were sorted out the truly productive part of the testing could be conducted. It was found that the standard ignition timing could be run with the reduced compression and 91 octane (R/M) fuel at 10 psi of boost. This lead of 6° BTDC was used for the duration of the tests. We feel that the knock authority used in the engine was working adequately to suppress any detonation, which was present. That is not to say that it is optimum only that it functioned well enough with the combination. Unless provisions are made to manually control the electronics at various loads and speeds no further testing would be profitable.

Tests were conducted to evaluate the microfueler size and location used on the dyno. Calculations are made in the development process to ascertain an approximate size for this component based on the additional need of the standard system when in a boost condition. After many were tried at the different power levels, which we were stepping up to, an optimum DYNO combination was found. The exact size calculated was found to perform the best in the engine on the dyno. This was a #009 injector size. It has been our experience that a size or two smaller than that found on the dyno is more realistic for use in the vehicle. It is for this reason that the final selection of microfueler size is conducted in the auto.

Microfueler location and its boost supply tap were the next problems to be addressed. The microfueler was initially positioned at a point in the system before the throttle body. This position proved to be poor due to the fuel being emitted from the throttle body seals under a boost condition. The position of this piece was then moved to the plenum area where it remained for the duration of the tests. The location of the boost supply tap was originally referenced from the idle air balance tube. This was a favorable position but was not used in the car. The injector cooling tube was also tried, but this location proved undesirable due to the fact that testing found this area to lag behind cylinder runner boost by about two psi. Although this had a favorable effect on low-end performance, this did lean out the top end A/F ratios to an unacceptable level. The final position, which was chosen, was the intake plenum area upstream from the intercooler. This was chosen mainly due to an ease of installation.

Next a series of cam timing tests were conducted to evaluate this with regards to engine performance. When the spacer was installed between the cylinder head and block, the stock cam timing marks no longer lined up. There was a decision to either advance or retard the cam for use with our combination. Both positions were tried to evaluate the performance. The torque increase from the advanced position did not match the increase in horsepower obtained from the retarded cam position. It was therefore decided to go with the retarded position in the test engine. It may be decided at a later time to go with the advanced cam position for our kit vehicles. The original test bed for this project would benefit with the chosen timing.

Next a turbo size test was performed to evaluate whether or not our initial choice was a valid one. There had been a great deal of backpressure with the Rotomaster turbo so it was felt that a larger size should be evaluated in order to compare the backpressure as well as the overall performance. We found that a horsepower increase was easily obtainable with the larger turbine size, but it did so at the penalty of low and mid range torque. The boost response was reduced to the point that maximum boost did not occur until after 5000 RPMS. Certainly this would be an unacceptable alternative in a drive-able situation.