Turbocharger FAQ

Frequently Asked Questions

Frequently Asked Questions: Hahn RaceCraft Turbosystems by Bill Hahn Jr.

What else will I have to buy?

NOTHING. Hahn RaceCraft Turbosystems are complete installation packages, with all the needed components included. We engineer each system for its application completely. You need only provide your car and an auto mechanic for installation. We've done all the hard work already.

Can I install it myself?

Yes, if you are a professional auto mechanic. Our systems and their installation manuals are intentionally designed to be installed by an auto mechanic, and do not require a turbocharger or tuning expert. We do not recommend that the average hobbyist attempt installation, however, unless he or she meets the above criteria. No fabrication is required, and all the needed parts are included. If you are in doubt as to whether you can install it yourself, you should probably consider an installation by a professional.

What if my installer or I need help?

No problem. Contact your dealer. Hahn RaceCraft chooses only dealers that can meet your technical needs: we are very picky about this! These dealers have direct access to our Tech Staff. If you purchased directly from Hahn RaceCraft, contact our Tech Department.

How long will a Hahn RaceCraft Turbosystem take to install?

About eight to ten hours for a non-intercooled system (varies with make and model). Intercooled systems will take an hour or two more to install.

Will my stock engine hold up to the additional power of turbocharging?

Yes. All Hahn RaceCraft systems are quite thoroughly tested for engine durability on our own in-house fleet of long-term evaluation vehicles. We are quite careful to set up our systems at power levels that maintain long engine life. And for those of you who need more, most Hahn RaceCraft systems stand ready to deliver even more power at higher boost on modified engines. Just follow the guidelines we set for your particular system level. Let Hahn RaceCraft engineering excellence take care of the rest!

Why do you use Mitsubishi turbos? Why not Garrett?

Mitsu turbos employ the latest, most advanced turbocharger wheel and housing design available. Period. For the flow range they provide, no other turbocharger we have found can respond as quickly while also being able to provide the airflow required for high HP. Mitsubishi achieved this through reducing the inertia required to spin their wheel assemblies. They achieved it by reshaping the wheels. For their flow range, no other wheel is as small in diameter (radially). This reduces the centrifugal inertia required to accelerate the wheel. How do they make up for the small diameter? The wheels are thick (axially). Net result: big flow, quick response. Add excellent efficiency through both low backpressure turbine sections and minimal heat added by the compressor, and you've got a winner. We have used these units for years on 25 to 30 PSI boost, 450 HP per liter engines with a ZERO failure rate! And when they do need freshening, it's easy, due to distributors located worldwide. Nothing else in my twenty years of experience has even come close, and they don't need exotic ball bearings to do it!

Why not an external wastegate?

No need. The additional complexity and expense is simply not required on these applications. We are able to achieve stable, consistent boost levels on these units with their internal actuator wastegates. Different boost levels are available through the different actuators we offer. And they all work wonderfully with boost controllers, electronic (preferred) or manual. Other turbo makes MUST use external wastegates, either because they do not exist with effective internal wastegates or due to improper sizing.

Do I need a front mount intercooler?

Unless you are ready to make over 400HP, our side mount intercoolers are optimal. We save you the additional purchase expense, longer installation time and permanent, irreversible changes a front-mount may require. You will also benefit from increased response due to the reduced intake volume a side mount intercooler presents. We have used the same intercooler design for years on our 350+ HP factory turbosystem upgrades. It works!

What about compatibility with my car's stock engine electronics?

We investigate and correct any engine management electronics issues on each system before it is released to the public. You should not encounter any problems.

Is the turbo always on?

The turbo is only activated when you apply more throttle. At cruising speeds, it does nothing to affect the car's drivability or mileage.

Will my fuel mileage suffer from the turbosystem?

MPG will be directly relative to the usage the car sees. If you can drive the car sedately enough to never achieve turbo boost, then the MPG will be the same as the car was with no turbosystem. Moderate use of the turbosystem will affect overall mileage only slightly. Our turbosystems are designed to be fuel efficient, yet safe for your engine.

What if my car already has an intake system and other modifications?

If you have already installed a header or air intake, these components will be replaced by components included in the turbosystem.

High flow cat-back exhaust systems are a good complement to the turbosystem, as are enhanced ignition system components. Internal engine modifications, such as cams, porting and compression changes, should be discussed with your installer.

Do I need a boost controller?

Boost controllers are not required, but are a nice addition if you wish to add versatility through multiple boost levels. They can also improve turbo response time.

WHAT DOES AND DOES NOT VOID MY FACTORY WARRANTY?

Click here for the real answers.

HOW DO I GET IN CONTACT WITH HAHN RACECRAFT?

Our hours are 9-5 Central Time Monday through Friday. Our phone number is (630)801-1417, fax number (630)801-7675. You can e-mail us questions on product and get price quotes at sales@turbosystem.com . You can get answers to time in transit questions and shipping costs at shipping@turbosystem.com and any comments or questions regarding this website can be sent to feedback@turbosystem.com .

Ref: http://www.hrchahnracecraft.com/auto/faq/faq.htm

Turbocharger FAQ

Q: How does the turbocharger work?

Subject: Re: [RAM] Turbo Operation info .....
From: Drdonnelly <Drdonnelly@aol.com>

The exhaust gases are split by the manifold into 1,2,3 and 4,5,6 which means that the exhaust pulses are balanced by the firing order of 1,5,3,6,2,4--sequential pulses to opposite halves of the manifold. The two passages lead into two ports in the exhaust or turbine housing of the turbocharger. These ports turn in a circle around the shaft of the turbo and also get smaller as they go around. There are slots all the way around that lead into the center point, to the turbine fins, so all the gases at some point in their rotation around the shaft centerline go through the fins and out the back end of the turbine housing to the exhaust pipe. The temperature differential combined with gas flow spins the fins, and the greater the temperature differential, the faster the turbo shaft will spin. The rate of spinning is not just airflow related, because boost, related to turbine speed, increases with fueling much more than with rpm.

The turbo shaft is spinning because the exhaust fins (vanes or blades) are turning from the exhaust going through them. On the other end of the turbo shaft is another set of fins that move intake air, compressing it and pushing it out through a compressor housing. This housing works in the reverse of the exhaust housing. This compressed air is the "boost" that goes through the aftercooler and into the intake manifold.

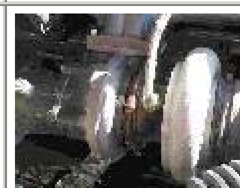
Why use a turbocharger instead of a supercharger driven by the engine or an electric motor?

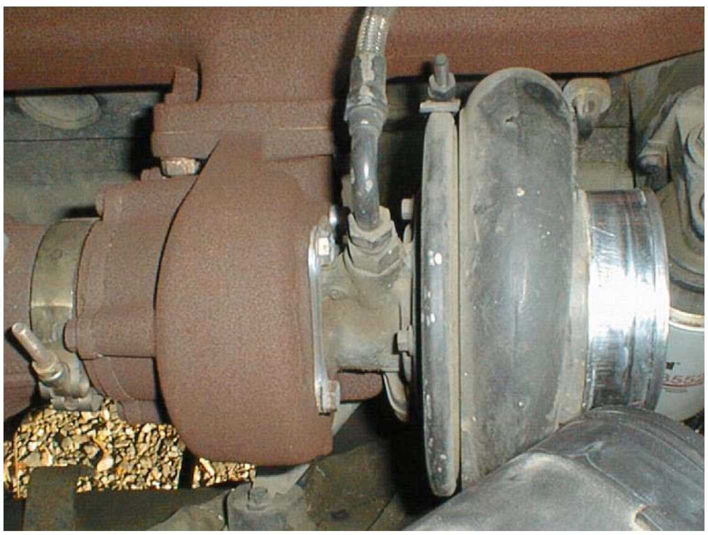
First, lets look at how much power the turbo compressor is using. These figures came from a Cummins/Holset presentation at a TDR rally:

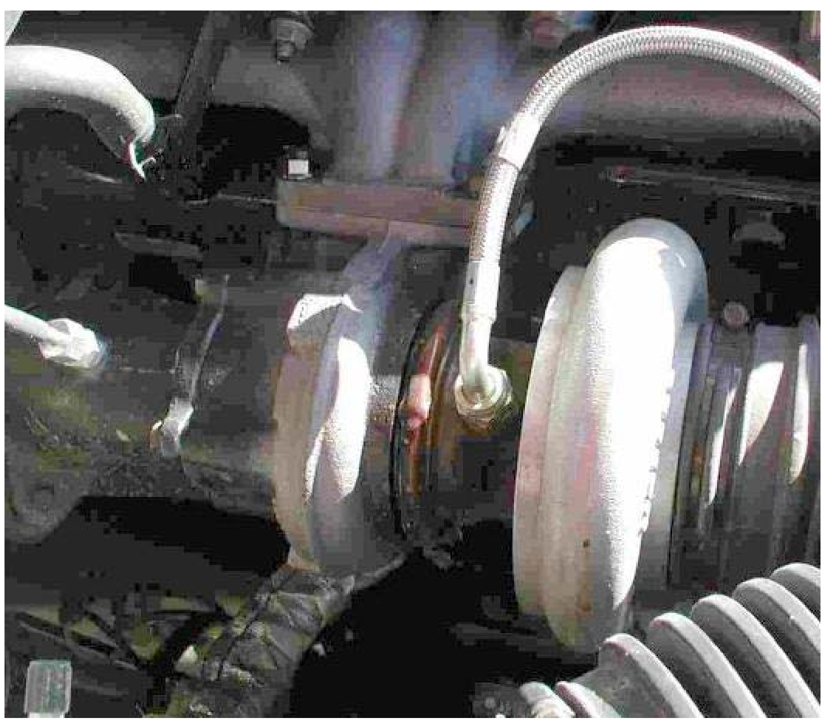
> Generally, 1/3 of the heat energy obtained from burning the fuel in the cylinder is transfered to the crankshaft in a diesel engine. Another 1/3 of heat energy is dumped into the cooling system, and the last 1/3 escapes through the engine exhaust. This means that an engine producing 100 hp at the flywheel also dumps the equivalent of 100 hp into the cooling system and another 100 hp into the exhaust system.
>
> Now, a well designed turbocharger converts 1/3 of the heat and pressure in the exhaust stream into compressor power. This means that an engine producing 100 hp to the drivetrain is using 33hp from the exhaust to power the turbocharger. At 200hp (near full throttle), the turbocharger in a Cummins B will extract 66 hp from the exhaust to power the turbocharger.

So, where does that leave us?
Up to 80 hp (for a 245 hp ETH engine) of relatively "free" power is being used to power the turbocharger compressor. It would take a very large electric motor to produce 80 hp, and power for this motor would have to be produced by the engine alternator, which would consume that much power from the engine to generate the electric power. Likewise, an engine driven supercharger would remove up to 80 hp from the crankshaft to power the compressor.
Bottom line: A turbocharger uses the waste heat to produce boost, without consuming fuel to power the compressor.

Which turbocharger Is On My Truck?

Turbocharger Identification				
HX 35 Turbo Housings		**H1C/WH1C**	**HX35W Turbo**	**HY35W Turbo**
PN cast on turbo housing:	Turbo housing size (cm2)			
3519297	21			
3519410	18			
3522778	18			
3521927	16			
	14W	Bolted & Clamped Construction	Bolted Construction	Clamped Construction
	12W			





Ram Diesel Turbocharger Specifications (stock engine)					
Year	Engine Rating	Max Boost Range	Wastegate	Holset Turbocharger	Turbine Housing (sq cm)
89-90	160 HP	22-25 psi	22 psi	H1C	18
91-92.5	160 HP	15-19 psi	17 psi	H1C	21
92.5-93	160 HP (CPL 1579)	18-21 psi	19 psi	H1C	18
94	160, 175 HP	15-18 psi	17 psi	WH1C	12
94	160, 175 HP	15-18 psi	17 psi	HX35W	12
95-98	160, 175, 180 HP	15-18 psi	17 psi	HX35W	12
96-98	215 HP	21-23 psi	23 psi	HX35W	12
98-00 ETC	215, 235 HP	18-20 psi	20.8 psi	HX35W	12
01 ETC	235 HP Auto and Manual	20.5 psi	23 psi	HY35W	9 single port
01 ETC	235 HP Manual	20.5 psi	23 psi	HX35W	12
01 ETH	245 HP	20.5 psi	26 psi	HX35W	12

Why is the HY-35 turbocharger used on 2001-2002 trucks with an automatic transmission?

A truck with an automatic transmission has to meet soot emissions standards when torque converter slip allows the engine accelerate quickly. This does not usually happen with a manual transmission because for the engine speed to increase, the truck must accelerate - and that takes time. The HY-35 builds boost a little more quickly than the HX-35 does when the engine load is light, so from an emissions standpoint the HY-35 is better suited to stop-and-go driving with an automatic transmission.

FWIW: The HY-35 and HX-35 are functionally equivalent under most engine loads, and the wastegates on both turbos are set for the same boost level. The HY-35 does not breathe as well as the HX-35 at higher speeds under a heavy load. The choke point of the HY35 is around 35psi; the HY35 chokes at about 29psi.

What is the "intercooler" and what does it do?

- When a gas is compressed into a smaller volume, both the pressure and the temperature of the gas increases. The same thing happens when the turbocharger compresses the intake air charge. To reduce NOx pollution and improve engine efficiency, the Ram uses an aftercooler to remove some of the heat from the intake air.
- The aftercooler is behind the grill and appears to be a second radiator.
- Note: Technically, the Ram Cummins uses an aftercooler. An intercooler is an intermediate charge air cooler between two stages of turbo charging and/or supercharging. An aftercooler is a cooler following a turbocharger or supercharger.
- The Ram intercooler is constructed of aluminum.

What is a "silencer ring"?

- A silencer ring is a metal baffle placed into the turbocharger inlet to reduce whistle from the turbocharger. It is installed in Ram truck engines at the request of Chrysler. The silencer ring has no effect on engine output, EGT, or boost levels.
- Removal: Remove the flex hose from the front of the turbo that goes to the breather. Just inside the turbo, you will see a snap ring that looks like a piston ring(charcoal color), very gently with a small flat blade screw driver, lift one end of the snap ring out of the groove, then continue to work around the snap ring, lifting it out of the groove. When the snap ring has been removed, you can easily remove the silence ring. R&R Instructions from Holset: Inletnew.pdf

Turbo With Ring

Turbo Without ring

What is "boost"?

- Boost is the pressure above atmospheric pressure (in psi) that the turbocharger generates. Boost pressures are slightly less at the manifold than they are at the turbocharger outlet due to cooling and expansion of the air charge as it passes through the intercooler.

What does the "Wastegate" do, and does it work along with "Boost"?

- The simple explanation: a wastegate limits the maximum boost generated by the turbocharger.
- How it works and what it does: The wastegate uses a pressure activated diaphragm and rod to operate an exhaust bypass around the turbocharger and thus limit the maximum boost that the turbocharger can produce. This permits an engine manufacturer to use a "fast" turbo charger with a small exhaust housing to produce useable boost at low engine speed and load. To prevent excessive boost at higher engine speeds, the wastegate limits the maximum boost to a safe level for the engine, and prevents turbocharger over-speed.

From Joe D.

The factory uses a small exhaust housing so that boost can be built very quickly, like small tube headers induce exhaust flow faster. However, the turbo could overspeed and/or the exhaust restriction from small exhaust housing ports could choke the flow and horsepower at higher rpm. Therefore, a wastegate is used. A hole, about 1" diameter, is drilled into the side of the rear exhaust housing port. A flap valve connects this hole to a bypass port leading directly to the exhaust pipe. Therefore, when the wastegate opens, some of the exhaust flow is bypassed from the turbine fins. This wastegate helps to limit total boost, because it opens at a preset amount of boost. Enough gas is bled off so that boost effectively is limited to that value (18-23 lb for most B engines). The higher rpm hp is still choked by the small housing ports, but for emission purposes, it is more important to build some boost very quickly so that fuel can be allowed without smoke.

The wastegate operation is simple. A pressure line goes from either the compressor housing (e.g. the 180 hp engine) or from the intake manifold (via a T fitting on the AFC housing on top of the injection pump governor) over to a pressure motor attached to the turbo exhaust housing. The wastegate flap is held closed by the heavy spring in the pressure motor, through a linkage. When boost pressure to the pressure motor overcomes the heavy spring, the linkage opens the wastegate flap.

Can I turn up the wastegate for more boost to increase the power output?

Turning up the wastegate will increase the air volume that is stuffed into the cylinder. This *may* reduce the EGT, but will not increase power. How do you get more power? One way: more fuel = more power. To increase the power, the fuel rate must be increased. The boost should only be increased to match the fuel curve for smoke and EGT control. Several tests have been done where a truck was run on a dynamometer, the boost was increased by blocking the wastegate signal, and the truck was re-tested on the Dyno. In every case reported, no power increase was measured.

The 12 Valve engines do not have a problem with excessive boost. For improved performance on pre 94 engines, a 16 sq cm turbine housing is usually the best compromise between low speed boost and high speed exhaust restriction. The stock 12 cm housing on 94+ engines is OK up to about 240 HP, beyond which the small housing restricts the exhaust and raises EGT. A 16 cm housing provides enough low speed boost for an enhanced engine, and the exhaust runs cooler at high speed.

The engine computer on ISB engines is designed to prevent excessive torque from causing damage to the drivetrain, and monitors the boost for "excessive" power. The computer will reduce the fuel rate (cut back the throttle - it is throttle by wire anyway!) when the boost exceeds 21 psi on 215hp and 235hp engines.

From Cummins:

Cummins builds engines with the proper combination of turbocharger, pistons, timing, camshaft and injectors to meet EPA regulations. Our Engineers determine what Holset turbocharger will produce all the right air flows and boost pressures to make the engine perform at a certain horsepower and torque and also meet EPA requirements. The EPA fine for modifying an engine that does not meet their regulations is $25,000 per occurrence.

Cummins does not publish turbo boost pressures, however, our data sheet and performance curves show maximum intake manifold pressure at full load and maximum rpm:

Engine Model (Dodge)	**Intake Manifold Pressure (max)**
6BT5.9-160 (12 valve) mechanical	34.0 in.Hg, 13.6 psi
6BT5.9-175 (12 valve) mechanical	38.0 in.Hg, 15.2 psi
6BT5.9-180 (12 valve) mechanical	39.0 in.Hg, 15.6 psi
6BT5.9-215 (12 valve) mechanical	51.0 in.Hg, 20.4 psi
ISB-215 (24 valve) electronic	39.1 in.Hg, 15.6 psi
ISB-235 (24 valve) electronic	40.0 in.Hg, 16.0 psi
ISB-245 (24 valve) electronic	51.0 in.Hg, 20.4 psi

NOTE: Remember that this is with the engine on the test stand, pulling maximum horsepower with dynamometer load making the engine work at 'full load'. It would be very difficult to duplicate maximum load on the engine in the vehicle.

We would recommend monitoring intake manifold pressure at the intake manifold, since that is where you would measure the amount of pressure going into the cylinders. You could do it at the cylinder head but the manifold is the preferred location. Due to charge air and after-cooling components between the turbocharger and engine cylinders, monitoring turbocharger output is not a true indication of air intake manifold pressure.

From Ted Jannetty:

Air fuel ratio has all to do with all internal combustion engines, in the case of Diesels

- too rich and you have soggy performance, black smoke and High EGT
- Too lean, i.e. more air than you need for proper complete combustion, Lost performance
- Too much boost, or more than you need causes many Deficiencies. High back pressure, high charge air temps, high egt. etc.

Everything is a balancing act. Simple test if you have a boost and egt gauge:

Lower boost a little at a time, you will see EGT drop then rise again as you go down, find the point were you have balance for you combo.

How fast does the turbocharger spin?

From the Holset Turbocharger Fundamentals page:

As you put your foot on the accelerator the wheel starts spinning faster. Small Turbos (e.g. Holset H1C's or HX35's) can spin at up to 140,000 rpm, that's 2333 revs per second or over 2000 km per hour.

What is the max. "allowable" boost pressure for 12 valve engines?

The HX-35 and HY-35 turbochargers are rated for a maximum boost of 44 PSI. To safely reach 44 PSI, the turbine housing MUST be sized to keep the choke point above 40 PSI. The 12 cm2 housing chokes at about 32 PSI and the 9 cm2 single port housing chokes at somewhere below 30 PSI, so be careful about pushing the stock turbocharger beyond 30 PSI!

From: Drdonnelly@aol.com

Well, Cummins used to say 30 psi was max, but no one running 35-40 has experienced failures related to the amount of boost, so now they seem to say 35 psi or so is OK! Of course, the turbo is spinning at or over 200,000 rpm. At any rate, the Rams don't see the upper boost levels and turbo rpm for much of a duty cycle.

From Dave F:

1 pound of boost for every 10hp is the maximum engine requirement. Overboost does not increase power. Excessive overboost increases the manifold EGT and reduces fuel economy due to the increased exhaust pumping losses. The "choke point" of a turbo charger is defined as the maximum exhaust volume the turbocharge can pass before exhaust back pressure rises drastically. Operating a turbo beyond the choke point is inefficient, drastically increases EGT, and can cause serious damage to the engine and turbocharger.

Good article from Bruce Malinson: "The compressed air or intake manifold pressure enters the combustion chamber and forces out the burned hydrocarbons or exhaust. This process is called scavenging the combustion chamber. Now, what happens when all of the exhaust doesn't get evacuated out past the exhaust valves and through the turbocharger? Simply put if the exhaust backpressure is greater than the intake manifold pressure, the exhaust will enter the intake manifold once the intake valve opens during valve overlap. This is not a good situation and you certainly don't want this taking place in your engine. The results of excessive backpressure are high exhaust temperatures, poor fuel mileage and a tight running engine. What do I mean by a tight running engine? If your engine feels like you always have to push it, your foot is always into the throttle, the engine feels as though its being choked at highway speeds it just doesn't want to glide along the highway, this is what I call a tight running engine. Too small of an air cleaner can also cause this problem, however in this article we are going to concentrate on the turbocharger and exhaust system. In today's society everybody wants more boost or intake manifold pressure and to obtain more boost you decrease the size of the turbine housing (exhaust housing) of the turbocharger. Now that the exhaust has to pass through a smaller orifice or turbine housing, the velocity of the exhaust increases and the turbine wheel (exhaust wheel) spins faster which in turn spins the compressor wheel forcing more air into the intake manifold. Now all of this may sound good so far however once the size of the exhaust housing is decreased the piston on its upstroke must now work harder to force the exhaust out of the combustion chamber through the turbocharger."

If I have turned up the injection pump, can I simply disable the wastegate instead of adjusting it?

From Ted Jannetty:

You Do need a wastegate for many reasons;

1. to control turbine shaft speed and keep it at a safe limit
2. to control back pressure in the exhaust manifold.
3. to prevent excessive heat in charge air.
4. to control boost so proper Air/Fuel ratios are maintained.
5. to prevent HIGH EGT from backpressure.

21 Psi will support 350 hp flywheel with clean tail pipe and EGT well within spec. When you raise boost you raise charge air temp which in turn raises EGT for all reasons listed above.

Every turbocharger is sized to run at a specific boost level, where the turbo can make COOL Boost, when you go above that it makes HOT boost, NO GOOD!!!

So many people are concerned with backpressure when it comes to turbine housing size, BUT NO ONE takes that in to consideration when disabling wastegates.

Don't do it You Don't Need it, it won't make any more power, Probably less.

When my throttle snaps closed, there is a brief whoosh or whistle sound from the air filter area. What is causing this?

When the engine is loaded, very high turbine speeds are required for the turbo charger to provide intake manifold boost. When the fuel is suddenly cut off, the exhaust volume collapses and the turbocharger rapidly spins down. As the turbine looses speed, it looses it's ability to sustain the manifold pressure and compressed air rushes backward from the manifold and through the turbocharger. The momentary airflow reversal is not harmful and produces the short pSSHTT sound.

How long should the engine idle to cool the turbocharger bearings?

This is from the Ram Service Manual

- Stop & Go, Load - Empty, Turbocharger temp - Cool, Idle Time...Less than 1 min.
- Stop & Go, Load - Medium, Turbocharger temp - Warm, Idle Time - 1 min
- Highway Spds., Load - Medium, Turbocharger temp - Warm, Idle Time - 2 min.
- City Traffic, Load - Max GCWR, Turbocharger temp - Warm, Idle Time - 3 min
- Highway Spds., Load - Max GCWR, Turbocharger temp - Warm, Idle Time - 4 min.
- Uphill Grade, Load - Max GCWR, Turbocharger temp - Hot!!, Idle Time - 5 min.

My cool-down comments -

- The general recommendation is to allow the exhaust gas temp to drop to 300 degrees before shutdown. Some say 350 degrees is OK but I prefer to take the temp down to 250 degrees because the exhaust manifold and turbo housing are heavy cast iron pieces that can store a considerable amount of heat energy.

- Using the EGT gauge to monitor cool down, my experience has been:
    - Most driving only needs only a minute of idling to cool the EGT (just below the turbocharger) to 250 degrees.
    - On Interstate highways, a long coast down the exit ramp quickly cools the exhaust to 200 degrees and then I allow the engine to idle for a minute so the heat stored in the turbo housing has a chance to dissipate.
    - If I have been dragging a trailer and have no "coast" time before I park, it takes several minutes to cool the EGT to 300 degrees.
    - If the turbo is hot from a long pull, pop the hood when you shut down (if don't mind gawkers).

-- Dave --

From the Holset opertaing procedures page:

- Before shutting your engine down, let the turbocharger cool down. When an engine runs at maximum power/high torque, the turbocharger is operating at very high temperatures and speeds. Hot shut down can cause reduced service life which is avoidable by a minute or two of idling.
- Avoid running your engine for long periods in idle mode (greater than 20-30 minutes). Under idling conditions, low pressures are generated in the turbocharger which can cause oil mist to leak past seals into the two end housings. Although no real harm is done to the turbocharger, as load is applied temperatures increase and the oil will start to burn off and cause blue smoke emission problems.

What is the max Allowable Exhaust Gas Temp?

Engine Load	Exh Manifold	Turbo elbow - Sustained*	Turbo elbow - Peak
Torque Peak	**1250° F**	**810° F**	**900° F**
Rated Power	**1250° F**	**950° F**	**1000° F**
* Aproximately = 1250° - (10° x boost psi)			

Exhaust Temp discussion form From the Cummins Mail list

Subject: Re: 1997 Dodge Cummins Max boost PSI?

From: Josh Berman <j.e.berman@metc.cummins.com>

Date: Tue, 22 Oct 1996 10:14:33 -0500

To: cummins

At 09:27 10/22/96 -0500, you wrote:

> I just installed an exhaust temp, boost pressure and engine oil temperature

> gauges on a 1997 Dodge 215 hp Cummins pickup truck. What are the "normal"

> and Max values, especially for the turbo boost?

Lucky you! Is it your truck, or were you helping out a pal? Here are some #'s for the 215 HP Dodge rating:

Factory Ratings	Torque Peak (134 HP @ 1600)	Rated Power (215 HP @ 2600)
EGT:	**810 deg. F**	**950 deg. F**
Boost:	**13 psi**	**25 psi**

Oil Temp: should not exceed 250-260 deg. F at any time (oil tends to break down, drastically reducing its life, if it runs at temperatures higher than 250-260 deg. F)

--

Joshua Berman MidRange Service Cummins Engine Company

j.e.berman@metc.cummins.com Cummins Homepage: www.cummins.com

What is likely to be damaged by high EGT?

From Joe Donnelly:

- exhaust gaskets
- exhaust manifold
- cylinder head casting
- pistons
- rings
- cylinder bores

Which cylinder runs the hottest?

Cylinder #1 has an obstruction of the intake port caused by a casting boss for accessory mounting bolt placement plus a forward facing valve port which causes the intake air to run a maze to reach the cylinder. These reduce the airflow to the #1 cylinder, causing it to run richer than the other cylinders. Often, the exhaust manifold gasket has been cooked on cyl #1, while the others are fine.

Subject: Re: boost and exhaust temperature

Date: Tue, 4 Feb 1997 10:04:01 -0800

From: Blaine Hufnagle <powrlftr@ix.netcom.com>

To: cummins

At 07:24 2/4/97 -0800, you wrote:

> 1. Max boost is about 25 psi, and exhaust gas temperature (egt) is about
> 1200-1250 degrees (probe in the exhaust manifold, about 0.7" before the turbo
> flange). Are these correct? I have heard about the 25 psi before, but the
> egt is a lot higher than Josh Berman showed for cpl 1550 at 900 in the
> manifold.

This sounds AWFULLY high. Your turbo housing *should* be glowing red hot at these temperatures, as should your exhaust manifold. (Look at them after dark with no lights.)

Mack recommends that exhaust temperatures never exceed about 1000 degrees or so (*below the turbo*). The ones I've seen, when loaded 12,000 lbs over gross weight, will run "only" about 800 or so, under full boost of 28-30 psi. Mack also recommends that you never exceed about 1050-1100. They say to "reduce engine power or downshift" to bring down engine temperature.

> 2. What egt is safe max for instantaneous, brief, and prolonged periods for
> my cpl?

I'd say Mack's recommendations are pretty close to right on.

> What "safety factor" is built in here?

Absolutely none. Remember that most oil will burn at about 450 degrees (that's with a FLAME.) The turbo is oil-cooled. Even though it has a high flow rate, you can't take that much heat out that fast.

Indeed, the cast-iron turbo housing and exhaust manifold start glowing around 1150 or so. It is worth noting that the crystal structure of iron-base metals changes at 1200 degrees, and as such 1250 degrees (give or take a few) is the post-heat temperature of choice for tempering in the "quench and temper" process. (I can go into the metallurgy if necessary by request.)

This is perhaps the most important reason to have a cool-down period of three to five minutes at idle when you've come in and parked, especially after a loaded run. No-load exhaust temperatures are well under 300 degrees (the lower limit on Mack pyrometers). The cool-down time allows the moving exhaust gas to cool the turbine and housing, and the high oil flow will cool the rest of the turbo down to something a little less resembling Hell itself.

NOT doing so is THE fastest way to coke a set of turbo bearings.

> 3. In December, Josh Berman wrote that the wastegate allows use of a smaller
> turbo housing for faster boost, without raising cylinder pressures too high.
> I have read that the early trucks (1989-90) used an 18 sq.cm. housing, and
> gave up to 25 pounds of boost also. I read the 215 hp uses a "different"
> turbo from the other 96-97 trucks. Is that just the wastegate opening
> setting, or is the housing bigger/smaller?

dunno, but you've got to flow a little more gas (and of course, fuel) to get the torque required.

> As a comparison with the early
> truck's turbo, what would be the max boost from my turbo if the wastegate
> didn't open/wasn't there?

A wastegate simply allows the exhaust gas to bypass the turbine and hit the exhaust pipe directly. I'd assume that the boost available wouldn't change at maximum, as the wastegate is closed at that time, and doesn't effect max pressure, except maybe to limit it at times when it's not really needed (such as coming down from speed). But I'm not sure as to the method of operation on how it actually does this.

I was always under the impression that wastegates allowed the use of a smaller turbo (to increase spin-up rates) while keeping maximum pressures manageable at high-speed. Can someone correct me?

> I gather the housing on my turbo is smaller than
> 18 sq.cm. to bring in boost earlier. If the wastegate sticks open, I suppose
> I would get no boost, and egt would be too high (?) and power low.

EGT won't go up unless boost goes up. There's a direct correlation between EGT and engine load. There's also a correlation between engine load and manifold pressure. Since you won't be getting manifold pressure high enough to fully load the engine, you won't ever get the EGT up high enough to worry. (or so I thought.)

> wastegate stuck closed, and boost climbed (to what pressure?), at what point
> would a problem develop, if any?

I'd imagine you'd be safe to 30-35 PSI or so... Although I wonder if you'd get that high. The Mack I drive at work is equipped with a boost gauge, and the highest pressure I've ever seen peaks at just under 30 PSI. Note that this is loaded to over 90,000 lbs and going up a grade. Normal cruise boost runs a "sedate" 12 psi or so. (note: this is on a Mack E7-350 V-MAC.)

-blaine

Subject: Re: boost and exhaust temperature

Date: Tue, 4 Feb 1997 13:57:31 -0800

From: Blaine Hufnagle <powrlftr@ix.netcom.com>

To: cummins

At 14:06 2/4/97 -0500, you wrote:

> my service manual ('90) says max exhaust gas temp of 1290F... and max
> manifold pressure of 26psi. it, however, does not state where the
> *STANDARD* measurement location should be...

Mack's MAP sensors are a hole drilled in a seemingly random location in the manifold, although I've seen the sensors usually placed alongside the #4 cylinder.

Mack places the pyrometer thermocouple about six inches DOWNSTREAM of the turbo.

> a conservative operator would do well to heed Blaine's comments above...

You might be surprised to find out that only a half a dozen or so fellow drivers (out of about 50) follow these suggestions at work; most of them charge full throttle into the yard, then immediately shut down. God only knows what kind of damage is being done.

Even though said practice is actually mandated by stickers in the cab...

(I learned said tactics when driving a turbocharged John Deere as a youth.)

>> (the lower limit on Mack pyrometers). The cool-down time allows the moving
>> exhaust gas to cool the turbine and housing, and the high oil flow will cool
>> the rest of the turbo down to something a little less resembling Hell itself.
>>
>> NOT doing so is THE fastest way to coke a set of turbo bearings.
>> again, Blaine has echoed my practice and is well to be heeded...

Also probably why the failure rate of automotive (i.e. sports car) turbos is so high... Scream into the garage and immediate shutdown.

For those of you who do not desire to babysit your vehicle for three to five minutes after running, there are idle timers available to do the job for you.

>> EGT won't go up unless boost goes up. There's a direct correlation between
>> EGT and engine load. There's also a correlation between engine load and
>> manifold pressure. Since you won't be getting manifold pressure high enough
>> to fully load the engine, you won't ever get the EGT up high enough to
>> worry. (or so I thought.)
> Blaine, are you sure on this one?

Actually, I seem to have stuck my foot in my mouth. :-)

Boost won't go up until EGT goes up, by definition: The turbo extracts the energy to provide boost from the heat in the exhaust. If there's no heat, there's no boost.

> it *seems* that with no appreciable manifold pressure, the governor will be trying
> to give full-fuel and egt would skyrocket...

All the extra fuel will do is make soot. As manifold pressure increases, soot will decrease. Under the conditions you specify, the fuel isn't being burned completely, thus maximum heat isn't being generated. The exhaust won't start to get hot until the boost starts to come up; it's a process that feeds itself. The low-MAP EGT will come up slowly, thus giving the turbo the energy it needs to function, but it won't really get started until the engine can produce enough gas flow for the thing to behave itself (around 1100 or so RPM in most industrial motors.)

> really-California-ish)... and you'll soon overload the engine, if manifold pressure
> never builds

Well, I'd assume anyone smart enough to drive one wouldn't leave an engine in this condition long enough to overload the engine; they'd change gears (or the tranny would do it for them, in the case of a slushbox) and get the engine into an RPM range where boost and power can be better utilized.

In older engines where smoke limiters aren't used, this condition often winds up hard-lugging the motor, great clouds of sulfurous smoke, but bringing it up to speed pretty fast.

> (it'll behave like an unaspirated engine with an intake and exhaust restriction,
> won't it?)

Probably. But remember that at low RPM's, those restrictions are actually your friends, as they keep flow velocity high and thus increase your combustion potential.

> my feeling here is that the hoses leading into/out-of the aftercooler
> (in the Dodge application) would blow-off the fittings before
> engine-damage would occur

I dunno... I'd imagine they could safely handle at least that much... Also worth noting is that you could blow intake/exhaust manifold gasketry....

> (you *sure* do not want to have manifold pressure great enough to unseat the
> intake valves... think about exhaust valves and exhaust brakes, too... :) that's why
> you need heavy-duty exhaust valve springs with an exhaust brake...)

I'm not sure here... There's twice as much valve motion when an exhaust brake is in action than when not in action; I think the heavier valve springs are to prevent valve floating, not hold exhaust side pressure.

Or are you talking about an Extarder(tm) versus a Jake Brake?

-blaine

Subject: EGT & Boost
Date: Thu, 27 Mar 1997 11:43:48 -0500
From: Josh Berman <j.e.berman@metc.cummins.com>
To: cummins

Hi everyone,

This is getting back to a thread that was raised at the beginning of February... what are the "limits" on EGT and Boost? Well, we typically quote EGT specs measured a couple of inches downstream of the turbo (after the turbine wheel), because this allows the thermocouple to be in a cooler exhaust stream (=longer life), and it is also safer for the turbo (in case the probe breaks off, the turbo doesn't eat a chunk of metal at 90,000 rpm).

That being said, the limit for CPL 1550 ('95 manual, 175HP @ 2500RPM, Chrysler rating) is 900 degrees F, and the limit for CPL 2023/2175 ('96/'97 manual, 215HP @ 2600RPM, Chrysler rating) is 950 degrees F. It's not that we're that concerned about the temperature of the exhaust after the turbo; we're interested instead in what we call TIT (Turbine Inlet Temperature). If this gets too high, then you start to think about damage to manifolds and turbos. Since turbos typically drop 200-250 degrees F across the turbine, and the limit for CPL 2023/2175 is 950 F, the max TIT you should see is right around 1200 F.

Now, that's not to say that your EGT CANNOT exceed 950F, but if it does, it shouldn't be for long. Short excursions to high temperature are unlikely to damage the turbo, but if you run at high temps for a long time (tens of minutes), you're probably asking for trouble in the long run.

Joe asked about what would happen if his wastegate stuck closed/open. If the wastegate stuck closed, you'd get a LOT of boost at rated. I don't know exactly how much, but it's a lot. You would also overspeed the turbo, which might lead to turbo failure. However, if the wastegate stuck open, you would be in much better shape (so to speak). If you look carefully at your fuel pump, there is a small line running from the manifold to the fuel pump. This is the AFC (Air Fuel Control) line, which allows the fuel pump to compensate for boost. We have to have this because if you floor the pedal @ idle (no boost), and the fuel pump delivered all the fuel it would when you floored the pedal @ full boost, you'd get a lot of black smoke. So, when the boost is low, you get what we call "No-Air Fuel". As the boost comes up, you get more fuel. If the wastegate stuck open, you'd never build boost, so you'd never get off of no-air fuel, and you'd have low power.

You can have a similar problem if the AFC line gets a hole in it. You will still build most of the boost (though some of it will leak out of the hole in the AFC line), but you won't get more than "No-Air" fuel, so you will still have low power.

As far as the old/new turbos go, there is difference in boost: for example, the '93 160HP engines have a max boost of 35 inHg (17 psi), while the newest '97 215HP have a max boost of 51 inHg (25psi). The new trucks do use a new design turbo, but I don't know exactly why it was changed (some serviceability, some performance, some ???).

I hope this is interesting. Feel free to post any questions; I'll try to answer them in less than the 1.75 months that this series of questions took :-)

-Josh B.

Joshua Berman (MidRange Service, Cummins Engine Company) j.e.berman@metc.cummins.com   Cummins Homepage: www.cummins.com

Turbo charging makes fun

To know more about turbos, this page provide enough explanation from how a turbo improves the output of an engine.

History of turbo

The foundation of turbochargers are derived from aerospace engineering. The introduction of turbo chargers to the automotive industry is first brought by a company Saab who is a great manufacturer of aircraft, but failed in the motors. Then the high technology is developed in the world famous F1 racing teams. After the F1 is banded from turbocharging, the Indycars carry on to develop the technology on racing engines, but they are forced to use a low boost pressure comparing the old F1's approximately over 3.5 bar of boost.

What is a turbo?

Turbocharger is a system with a turbine and a compressor connected coaxially inline with a common shaft. The compressor is driven by the turbine, and the turbine itself is powered by unwanted exhaust gas from engine. This can save the waste of throwing away with something high energy (hot burning high flow exhaust gas). The amount of thermo energy is probably 70% of the total thermo energy in the combustion process. Then the compression of intake air will work like a bigger sized engine with a small engine. It also befits the weight of the engine, by not increasing the engine size to keep the weight to minimum. A common turbo for a 2 litre engine weights about 5 - 8 kg, the engine itself weights over 80 kg. When a turbo compresses the air to 1 bar (14.7 psi or 1 atmospheric pressure unit), this doubles the air to the engine. How much weight will there be for a 4 litre engine relatively to the turbo? Then it improves the power to weight ratio which is ideal in aircrafts and high performance engines where weight is an important factor.

Green Action - be environmental friendly!

Turbocharged engine used to have a better emission, since the rate of burning a compressed mixture is much better than a normally aspirated engine. The use of exhaust gas energy decreases the waste of heat dumped to the atmosphere, part of its energy is used to compress the intake air and powers the turbine. Engine exhaust noise is eliminate by having the turbine at the exhaust manifold and blocking a lot of noise from engine.

Have you think of turbo charging your engine?

Something to be aware of

If you have an engine has a compression ratio of 9.5 or lower, turbo charging your engine makes fun and safe. Since it may doubles the power and torque of the engine but not doubles the load. It only probably increases 20% of power load to the engine. Isn't this interesting? The explanation of this will be given later on this page.

Why not allowing a 10:1 compression ratio for turbocharging? The turbocharger compresses intake air and delivers it to the engine. If you have a high compression ratio engine, that means the pressure build up during the compression stroke will be too high if your charged air is pre compressed from the turbocharger.

Too high? Why not? Due to the thermo property of air and petrol. Rapid compression of gases will result in rapid raise in temperature. A system like this is compressing the mixture very rapidly and thus may cause an explosion rather than a combustion reaction, this rapid rise in temperature and pressure will result in an abnormal operation and giving a few hundred bars rise in pressure and 10,000^{o}C may reach at the center of explosion. Does this sounds more power? Yes, it does, but it blows up your engine, what is your choice?

Why blowing up? The reason of this is because the uncontrolled reaction, such rapid pressure and temperature rising is considered an impact load to the engine, which is very harmful to engine pistons and con rods, but the head gasket is the first thing to blow away. There is nothing to resist detonation these days. The only way that to run high compression is probably running a rich fuel mixture by pumping more fuel into the charge air or using a high octane fuel, these approaches decrease the rate of burning by decreasing the concentration of oxygen. This also applies to normally aspirated engine with a high compression ratio. So the higher the compression ratio, the more rich you need for your fuel mixture. But the combustion chamber flow design will also affect the resistance of detonation, not just the fuel mixture. A good designed flow chamber will probably need less fuel to run high compression ratio, thus much more efficient.

Efficiency

Does turbocharging my engine makes it more efficient? Internally yes, but overall no. A compressed fuel mixture will increase its burning rate and achieve a better combustion process so it increases the output of your engine. When air moves through a narrow compressor (turbo inlet), this creates drag (air friction) to the inlet plus the back pressure of exhaust gas produced from the restriction of the exhaust turbine. The turbocharger acts like a restricter. The drop in compression ratio also looses relatively stroke length. If you know a little bit about chemistry or thermodynamics $W = PdV$, it actually decreases the overall efficiency of the engine.

Turbocharger VS Super Charger

Supercharger is an earlier design of force induction system. They are first used in aircraft engine as they require a small light engine with more power. The supercharger is a compressor driven by the engines output shaft (crank shafts in piston engines), the energy required to drive the shaft is part of the output of engine. So the output power is decreased and thus with have less efficient than a turbocharger who drives it self with an unwanted energy source (exhaust gas energy). The control of a supercharger involve mechanical connection to the engine, speed ratio to the engine is fixed, installing a gearbox for a compressor is meaningless. Control of a turbo is much simpler, the wastegate which is a valve in the exhaust manifold which controls the exhaust gas flowing through the turbine which indirectly controls the compressor's speed. This is more simpler than a mechanical connection and the opening time for the valve is variable at any time. Thus, the turbocharger is a replacement of superchargers in both aircrafts and automotive engines. *See the thermo efficiency page*

Judgement of using a turbo

The use of a turbo does not always provide benefit. Consider the turbo benefits the weight of your engine. In a cruise condition, where weight is not an important factor, the benefit from turbo is negligible. If the vehicle is under a frequent stop and go condition, the turbocharger will greatly helps the efficiency by keeping the weight to minimum. This is why turbos are used in high performance cars and trucks.

Selecting a turbo charger

When selecting a turbo charger for your car, the first thing to do is ask yourself what are you going to use it for? Have some fun on the street or serious power? If you having driven a turbo charged car, you will probably heard about the word "turbo lag", it feels like without the turbo until a particular high engine speed is reached. The reason of a turbo lag is that the turbo compressor need a surge on exhaust gas which is needed for power the turbine and speed up the turbo to a particular speed which can compresses air efficiently. If you did read the previous page, the turbo is a fluid mechanical device which is connected to the exhaust gas all the time, so the turbo is actually compressing air all the time, the turbo lag you felt or the turbo cut in point is actually the turbo is not compressing air in low exhaust gas flow rate and until a higher exhaust gas flow is reached. So what is relating in selecting a turbo charger? The key point is to select the efficient point of the turbo. Different size of turbo will have different efficiency of air flow and pressure. A flow map with efficiency points is usually provided when you buy the turbo charger. If power equals force by speed, then it means a turbo with an efficiency at high engine rpm (big turbo) will give you more power, but it creates more turbo lag. A smaller turbo will be more favourable in better driving around the street, but it lacks of power, since the efficiency of a small turbo will drop rapidly after the efficiency point is passed. The calculation of selecting a turbo is not more than pressure ratio (Absolute pressure ratio of exhaust manifold and boost pressure) or the calculation of air flow with desired boost pressure (see good engine example). Then a reference to the turbo flow map is needed. Calculate the air flow required in a range of usable rpm, for example 2500 - 5000 rpm on the street. Then look up the maps and select a turbo which gives an efficiency not lower than 60%. Varies the rpm range selection and this varies the power output of your engine. A list of flow maps will be listed on this page later and an example of selecting a turbo will be given.

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Problems of turbo

Although turbos have a lot of advantage over normally aspirated engines, but they still have trade offs. Such as slightly heavier fuel consumption on cruising, need frequent change of engine oil result in more maintenance cost, more stress to the engine makes the engine life shorter and less response comparing to normally aspirated engines.

Turbo Lag
When the engine is at idle, the amount of exhause gas is not enough to drive the turbine to produce boost, when accelerates in full throtle, the exhaust gas from engine drives the turbone and then the turbines starts to accelerate, before the turbine can reach the desired speed, the turbo is act as a restricter rather than a booster. This is where the point we ofter called "turbo lag", this refer to the spin up time of the turbine from idle to an efficient speed plus the delay caused to fill up the volume and pressurise of the intake pipings and intake plenum (intake manifold and tank).

The need of cooling down
When the turbo is connected to the exhaust system, large amount of heat is transfered to the housings, imagine when the turbo's main shaft is spinning at a speed of 10,000 rpm, how much heat is produced from friction? So continuous oil feed to the bearing is a must. After your engine is being stressed, a measure to the exhaust gas temperature reads out over 800 C. No such engine oil with withstand such temperature. If the engine is switched off at this time, the residue oil inside the turbo's oil line will be boiled and coked (burnt and harden) at the shaft and bearings. This is cause damage later when the turbo is again spining at high speeds. This may result quickly worn in bearings and cause the shaft to vibrate, then the turbine or compressor wheel starts to touch of scratch the housings internals, after a couple of scratch the blades are sheared off and imagine they are sucked to the engines intake! This is very dangerous. To avoid this, before the engine is switched off, leave the engine at idling (keep it to minimum load) so that the oil pump is still pumping oil throught the oil line and keep turbo system nice and cool. Typical cooling time for street cars are between 1 min to 3 min, it depends how much stress are you putting to the engine.?
Intercooling
Intercooling is achieved by cooling the charged air from the outlet of compressor before it reach the engine. Intercooling helps the efficiency of the compressor, since the thermo property of gas will raise itselves temperature due to rapid rise in pressure, this rapid rise in temperature will cause decrease in density of air. This is actually decreasing the mass flow rate of air to the engine, eventually loose power. It also helps more prevention in detonation, so it is also a safety device. The drop in temperature (drop in internal energy of gas) will also make easier to the compressor to flow air through, since it take less work to do to transfer air from low potential to high potential energy.

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Turbocharger developments
Turbocharger improvements has never stop. The turbocharger consist of a center bearing housing, a compressor and an exhaust turbine.

Roller bearings in turbochargers
Traditional turbochargers uses bushes and thrust bearings, they are cheap and easy to manufacture. In early days, only high performance race turbos use ball bearings. When roller ball bearings became cheaper in cost and the improvements of durability of ball bearings, they are introduced to street high performance turbochargers. The ball bearing type turbochargers reduces the friction and thus minimise the spin up time of the turbine shaft. comparing to thrust bearing turbos, the lag (spin up time) is minimised to one third of the original lab time. This is a great achievement done by ball bearings.

Improvements in cooling and lubrication
The most common type of turbocharger we are using is an oil feed lubricated type. The oil feed line are from engine's pressurised oil line and are feed to the turbo's bearing to lubricate and cooling. Due to the friction of the shaft and the exhaust gas heat. the bearing itself need a continuos oil flow to keep the bearing in working condition. This arise a problem of oil clogging or oil cooked at the shaft when insufficient oil flow or over heating the oil. This give arise to a water cooled turbocharger bearing. A water jacket is introduced at the center bearing housing, the engine coolant runs through the the jacket and recirculates with the main engine coolant channel and cool down at the main radiator. This can keep the oil temperature always below the coolant's boiling point.

Improvements in turbines
The traditional turbines are made of steel, some of them uses alloy steel even titanium. The mew material for engineers is

ceramics. Ceramics are able to resist high temperature with the minimum thermal expansions and are light weight. The use of ceramic turbines in turbochargers has become very effective in improvement of boost response and longer life. It is because the ceramic material greatly reduces the turbine's inertia and this reduce the turbine's spin up time. The longer life is that the thermal property of ceramics are much better than metal, the chemical resistance of ceramics make it the best engineering material in high temperature application. There is one potential of failure in ceramic turbines is the brittle property, if there is some pollutants in the exhaust gas and cause an impact with the turbine, it may fail immediately.

Variable area turbine nozzles

The newest type of turbo I ever know is the VATN (Variable area turbine nozzle), it ables to vary the turbine's area by having movable blades at the turbine wheel. The movement of the blades cause change in flow area and thus vary the turbine speed to control boosts. This type of turbo will not waste exhaust gas energy since it does not have a wastegate to let exhaust gas by pass, it varies the speed of the shaft to control the boost. It also allow to have the feature of minimising the turbo lag by decrease the flow area and then reduce exhaust gas restriction in high flow to acheive high power output. This can have both the advantage of both the small and big turbo.

The trend of turbochargers

The trend of turbochargers will be using ceramic turbines plus the use of ball bearings and water cooled bearing sections. Not high performance turbos use such configuration, even every turbo have the trend to use such configs to improve the turbo's life and reduce maintenance costs.

Ref: http://www.rcn.com.hk/~davidtl/turbo.html

HOW TO CHOOSE A TURBOCHARGER

"Which turbo?" That's the question we get right, the first time, every working day as we consult with performance enthusiasts and racers. Here's the short answer.

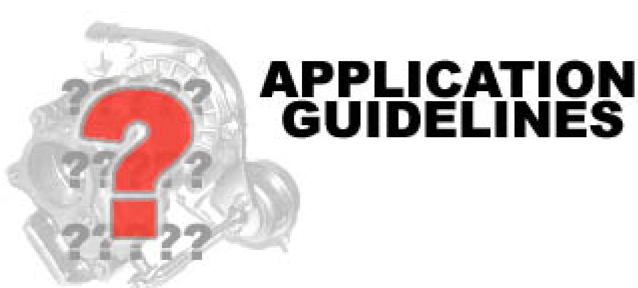
The selection of the best turbocharger for the job boils down to three questions.

1. What's the horsepower target? (be realistic.)
2. What are the engine's specifications? (displacement, number of cylinders, number of valves, compression ratio, volumetric efficiency, etc.)
3. What are the vehicle's specifications? (weight, operating RPM, max RPM, street car or RACE car.)

Give us realistic, accurate answers to the above and we'll put you where you want to be. We'll ensure the best results, save you time and money if you think through certain decisions and criteria. In other words, to build a faster car you need a plan. First you must decide on the intended use of the car: mainly street driving or racing only?
A race car is highly specialized. The goal is the ultimate horsepower within a narrow RPM range. But the trade-off is lousy power at low engine speeds. A street car, on the other hand, needs low-end response. If you're honest, you'll see that a street car can spend 90% to 95% of its time at 4000 rpm or less. This means a well-designed "driver" must pull strongly from idle.
What's very often missed by beginners who wake up and declare, "I'm going to build a fast car!" is that a properly engineered 300 hp street car will outperform a 600-hp race car on public streets and highways under normal driving conditions.
Other issues that need to be addressed include:

- ECU capability
- Injectors
- Fuel quality, pressure and volume
- Knock sensing
- Available space in engine compartment

Just remember that our specialty is providing the air. Fuel, ignition, exhaust, cooling, electronic engine control mapping, etc. are the responsibilities of the vehicle builder. What you get when you select a Turbonetics turbocharger and accessories is our knowledge and expertise in providing more airflow to the engine. In the vast majority of cases, we know what works for any given application. Our tech and sales department have highly specialized computer programs and flow maps to aid in the selection of your turbocharger. We don't buy into the one-size-fits-all mindset. That's why we don't have any completed turbochargers on shelves. Virtually every unit we sell is customized and blueprinted for your specific vehicle and application.



Be Sure to check out - [How to choose a turbocharger](#).

Note: This section is intended to provide general turbocharger sizing information, not solutions to specific turbocharger-engine-vehicle combinations. Typically, an optimized turbocharger match is the result of combined engine dynamometer testing and installed vehicle performance evaluation. Often compromises must be made to arrive at a match yielding satisfactory response, power, and fuel economy in a retrofit or special application. Estimated engine air flow requirements at varying RPM are plotted in Figure 1 for typical 5 psi and 10 psi boost levels, and in figure 2 for 10 psi and 15 psi (Intercooled, typical modern 4 valve/cyl. engine, or race “ported” 2 valve engine.) To determine air flow for a given size engine at maximum engine speed, read upward in Figure 1 or figure 2, to the appropriate boost and speed line. Engine air flow requirement is read directly by projecting the boost-speed point horizontally to the left.

Engine air flow requirements can be used directly in establishing an operating line on an appropriate compressor map. Refer to pages 18 - 23. Compressor pressure ratios corresponding to boost levels of 5 psi and 10 psi are 1.34 and 1.68, (1.68 and 2.02 in figure 2) respectively. Select a compressor such that the engine torque peak operating point is near to the compressor peak efficiency island as possible while maintaining the engine rated speed point in the compressor 60% or higher efficiency region. In the case of larger displacement engines with high RPM capability, it will usually be necessary to use two turbochargers to provide adequate air for the desired airflow / boost conditions. To determine operating points on a compressor map for a twin turbocharger arrangement, divide the total air flow found in Figure 2 in half, and select a map that will satisfy those conditions.

Do not attempt to establish an operating point in an area on a compressor map to the left of the surge line. This is an area characterized by unstable operation and violent flow reversal, potentially resulting in turbocharger failure. Turbine selection and a method of boost control for spark ignited engines must also be considered for a successful turbocharger match. Most turbochargers described in this catalog are not equipped with a wastegate or other device to bleed off excess exhaust energy when a desired boost is attained. Turbonetics, Inc. offers the DELTAGATE Mark II and the RACEGATE wastegate in several configurations to satisfy most applications.

Turbine selection is a variable based on intended use, weight, and desired response. Turbine power available to drive the compressor can be varied in two ways: 1) the Area to Radius (A/R) ratio of the turbine housing can be changed to alter turbine inlet pressure; and 2) the turbine wheel trim can be specified to effect an increase or decrease in turbine pressure for a given turbine housing A/R. (See data sheets for available turbine trim and housing information.) Initial recommendations for normal single turbocharger applications (assuming a controlled boost of 10 psi or less) may be selected as shown in the following table:

ENGINE DISPLACEMENT	COMPRESSOR TRIM	TURBINE TRIM	TURBINE HSG
60-100 CID	T3-50 Trim	T3 Standard	.36/.48
100-150 CID	T3-Super 60	T3 Standard	.48/.63
150-200 CID	T3-Super 60	T3 Standard	.63/.82
200-250 CID	T4-S3 Trim	T4 “O” Trim	.58/.69
250-300 CID	T4-V1 Trim	T4 “P” Trim	.69/.81
300-350 CID	T4-V1 Trim	T4 “P” Trim	.81/.96
350-400 CID	T4-H3 Trim	T4 ”P” Trim	.96/1.30
400-450 CID	T4-H3 Trim	T4 “P” Trim	1.30

High speed engines, heavy vehicle loading, special purpose vehicles, and applications requiring multiple turbochargers will require turbine configurations based on specific requirements and may vary considerably from above recommendations. Contact a Turbonetics turbo specialist for specific recommendations.

Figure 1
Engine airflow requirements for 5 PSI and 10 PSI boost levels.

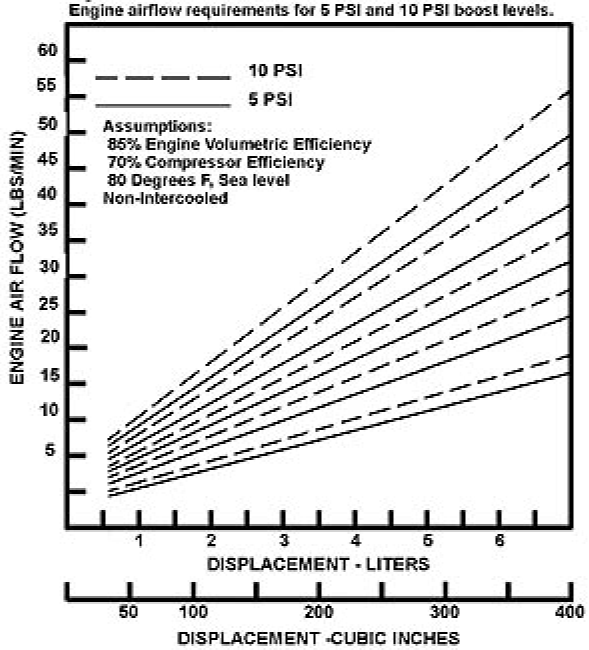
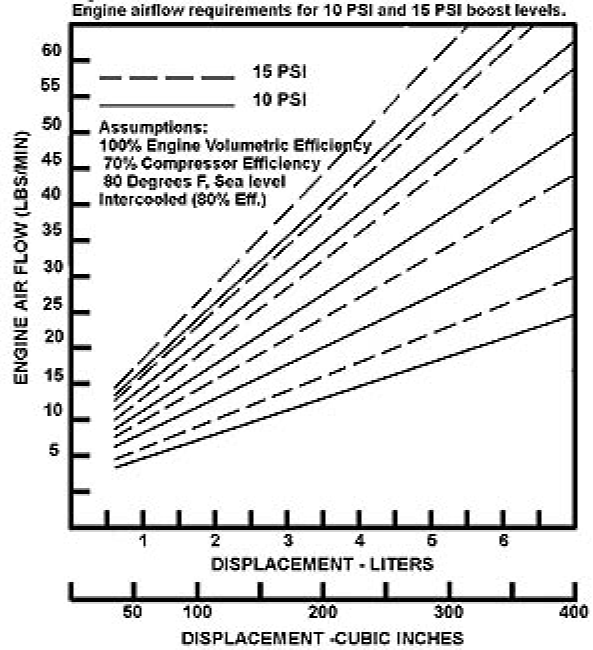


Figure 2
Engine airflow requirements for 10 PSI and 15 PSI boost levels.



Frequently Asked Questions

Updated: Dec. 17, 2001

Q: ***Do you make any kits or systems?***

A: **No. Turbonetics manufactures the turbos for many of the leading turbo-kit**

manufacturers in the market today. We specialize in working very closely with our dealer network. Our goal is to provide customers with the best-performing, highest-quality turbos in today's marketplace.

Q: ***Why do Turbonetics ceramic ball-bearing turbos only use one ball bearing?***

A: Turbonetics created the ceramic ball bearing turbocharger for durability. By utilizing a single, ceramic, angular-contact ball bearing on the compressor side instead of the more common bronze piece, the ball bearing can absorb the thrust loading that all too often can lead to turbo failure in high performance gas applications. The Turbonetics ceramic ball bearing turbo can withstand up to 50 times the thrust load capacity, compared to a conventional floating bearing unit.

****Dual ball bearing turbos can only withstand 2-3 times more thrust loading than standard turbos.***

Q: ***What is on the turbine side of the turbocharger in the ceramic ball-bearing turbochargers?***

A: The turbine side of the ceramic ball-bearing turbo uses a floating bearing to dampen the harmonics and vibrations that are transmitted through the turbocharger. This allows Turbonetics to balance the turbo to the most demanding tolerances.

Q: ***Do the ceramic ball-bearing turbos "spool up" faster than a normal turbo?***

A: YES! The ceramic ball-bearing design reduces the frictional loss that occurs with a conventional floating bearing-and-thrust system turbo. The ceramic ball-bearing design allows the turbo to accelerate much quicker, thus decreasing spool-up time. In most cases we have found our ceramic ball-bearing designs require 50 percent less energy to drive the turbo.

Q: ***What is a "hybrid" turbocharger?***

A: A "hybrid" turbo uses parts from two different families of turbochargers to create a completely new turbo to meet a specific need. This can be done with the same brand of turbos, or two different makes can be combined to form something totally new. An example is the T3/T4. This turbo uses T3 turbine parts combined with T4 compressor pieces to make a turbo that fits a certain horsepower and displacement range.

Q: ***How long does it take to perform an upgrade?***

A: Depending upon the complexity of the work, upgrades typically take 7 to 10 days.

Q: ***How much does an upgrade cost?***

A: It depends on the vehicle and the type of upgrade we are doing. Some cars have turbos that are more difficult to work on. Thus, the cost may be higher for one brand of car compared to another. Cost also depends on whether your stock turbo is in good condition. If your turbo needs parts before work can begin it will, of course, cost more.

Q: ***What is the difference between TO4E turbos and TO4Bs?***

A: They are related. The "E" and "B" signify different families of compressor wheels. Each family was optimized for certain applications. One family is not better than the other. In some circumstances, the "E" may perform better than the "B." In other situations, vice versa. The key is to choose which wheel works best for your vehicle's needs.

Q: ***Does Turbonetics build and upgrade all of the turbos at their plant in Simi Valley, California?***

A: Yes! All of the upgrades and new units are worked on and built in-house at our modern, state-of-the-art facility.

Q: ***What is the difference between an "on-center" turbine housing and a "tangential" turbine housing?***

A: These are the two styles offered with Turbonetics' T4 turbochargers. The difference is the way that they mount in the engine compartment and the manner in which the exhaust is evacuated from the housing. The "on-center" uses a standard T4 inlet flange, as well as a four-bolt discharge flange. The reason that it is called on-center is just that, the housing sits right on top of the inlet flange.

The "tangential" turbine housing differs both in form and function. The housing sits off to one side, similar to that of a snail shell. The other difference is that to connect an exhaust down-pipe, a V-Band flange-and-clamp assembly must be used. This setup sometimes proves to be more convenient for race applications. The "tang" housings are 4 to 5 percent more efficient in flow. Neither the "on-center" nor "tangential" perform better than the other. The decision to use one over the other should depend completely upon the installation of the turbos in the engine compartment.

*If you are still unclear, please refer to the turbine housing section of our on-line catalog or call one of our qualified sales people.

Q: ***Do I need to run water-cooling lines to the turbocharger?***

A: Water provides a certain margin of safety when the engine is shut off. Thanks to engine heat, coolant normally continues to circulate through the bearing housing, thus drawing heat away from the bearings. If the car is shut down properly and the engine is allowed to cool it is not mandatory to use water lines. Whether to use water lines depends on the convenience of plumbing the car and the vehicle's intended use.

Q: ***How much boost can my car run?***

A: Remember boost is *not* horsepower. Boost is just a measurement of how hard the turbo is working to force air into the engine. When an engine cannot flow any more air into it, the boost must be increased to force it in. Maximum boost is determined by the tuning as well as by the engine's internal components. It is the responsibility of the car owner and tuner to take steps that will ensure that the increased boost will not harm the engine.

Q: ***Will the turbo I get from Turbonetics bolt on to my car?***

A: It depends on whether you choose an upgrade unit or a custom-built turbo. All of our factory upgrades are a complete replacement and will fit directly back on the car after the work has been performed. If you go with a custom-built Turbonetics turbo, an exhaust manifold with proper positioning and flanges will be required.

Ref: http://www.turboneticsinc.com/faq.html

Ref: www.neons.org
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