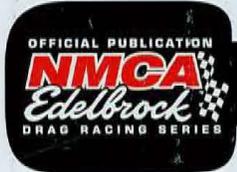


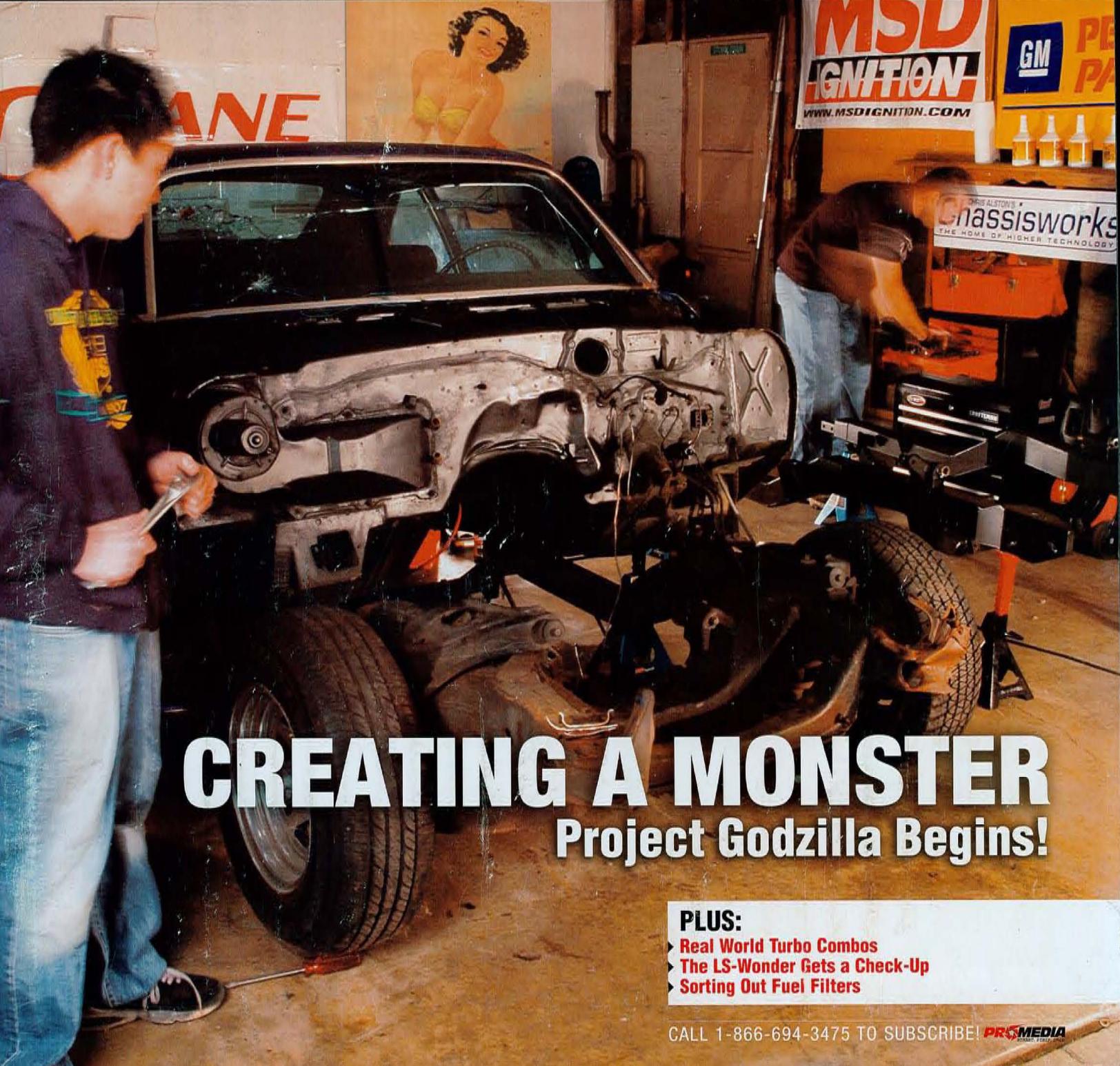
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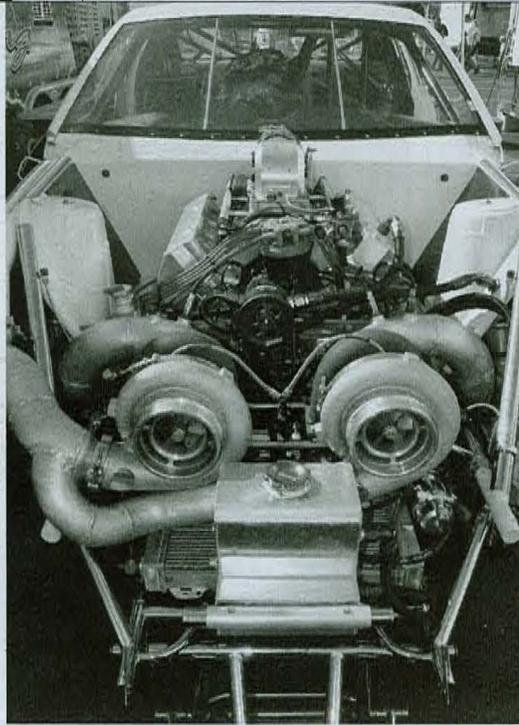
TURBO

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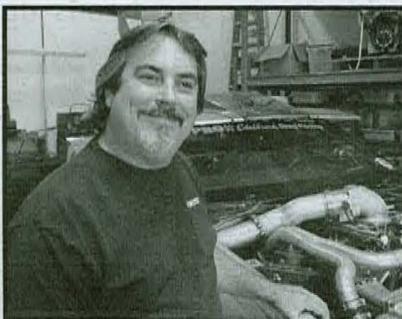
Written by Chris Spies
Behind the Lens: The Author and Manufacturers

Though it has been known for years that turbochargers are the way to make the most horsepower per cubic inch (Honda engineers had their Formula 1 engines making 1,000hp/liter back in the late 80's), cost and perceived complexity have kept them from moving into the spotlight among heads up racers until recent years. While a few adventurous racers were able to put up respectable numbers using mechanical fuel injection systems and drawing through carburetors way back in the 1960's, recent advances in fuel injection, carburetion and ignition systems have caused their popularity to skyrocket. While many old school racers have been reluctant to embrace the technology, those who have rarely look back. While the number of turbochargers found at a heads up event greatly surpass those of 10 years ago, the players in the market remain largely unchanged. These days, most turbo racers use units from: Innovative Turbo, Precision Turbo, Turbonetics and Exile Turbo (recently opened by Rick Head, formerly of Turbonetics and Innovative Turbo).



"Flipping a set of 'shorty' headers will not last long as they were not designed for the kind of temperatures and pressures of a turbo system."

—Rick Head, Exile Turbo



Twins vs Singles Rick Head, Exile Turbo

"I am a big fan of twin turbo applications. Any time you are not limited to a single turbo for any reason such as class rules or space constraint, twins are the way to go. When I build a turbo system I want it to look as good as it runs. It's a form of industrial art and a means by which the builder can express his or her artistic vision. Twins provide more symmetry and can in some cases be easier to package. Besides aesthetics, twins will be easier to stage in a drag race application, transition faster and easier to tune a linear power and torque curve. Especially when using a boost controller. It's easier to control "more than enough boost" (twins) than "not enough boost" to "too much boost" in a millisecond (single) if that makes any sense..."

		HORSEPOWER															HORSEPOWER																																													
		100HP	110HP	120HP	130HP	140HP	150HP	160HP	170HP	180HP	190HP	200HP	210HP	220HP	230HP	240HP	250HP	260HP	270HP	280HP	290HP	300HP	310HP	320HP	330HP	340HP	350HP	360HP	370HP	380HP	390HP	400HP																														
ENGINE DISPLACEMENT	1.8L TURBO	ASSUMPTIONS: Single Turbine - 90 psi Single Turbine Application Intercooler for All Applications Dry Breathing Blowing Optimistic Fuel Exemplar Turbine Housing (Minimums) 2.5" V-Belt (1/2 Exhaust Hose) Precision Fuel Feed Rotating Component Bearings Steel TX 1/2" Turbine (Standard Inlets) Electric - 4.0" (30" / 2.0" Discharge) 40 Noctis - 4.0" (30" / 2.0" Discharge) PDC - 3.0" (30" / 2.0" Discharge) EVAE - 3.0" (30" / 2.0" Discharge) ES - 3.0" (30" / 2.0" Discharge)																																																												
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	2.4L TURBO	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850	3900	3950	4000
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	3.0L TURBO	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850	3900	3950	4000
	3.5L TURBO	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850	3900	3950	4000
	4.0L TURBO	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850	3900	3950	4000
	4.6L TURBO	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850	3900	3950	4000
	5.0L TURBO	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850	3900	3950	4000

► The folks at Turbonetics have greatly simplified the task of selecting a turbo by constructing this turbo matrix which may be downloaded from their website: www.turboneticsinc.com in PDF form. This matrix allows users to determine the best fit for their desired engine size and power level. While this matrix is a great tool, Turbonetics intends for it to be used as a starting point, not a replacement for the expertise offered by their technicians.

TURBO

Got Boost?

MILD TO WILD TURBO COMBOS



► Courtesy of Exile - With a pair of these Garrett GT4508's in place, a rowdy 600hp small block can be transformed into a 2000+hp beast. According to Rick Head of Exile, these ball bearing equipped 81mm inlet units are capable of feeding 1100hp apiece. A quick look at the accompanying compressor map supports this claim as it shows airflow capabilities of 110 lb/min. What this map also tells us is that this unit will offer peak efficiency at a pressure ratio between 1.75 (11psi) and 2.75:1 (26psi) of boost.

This month, we are going to take a look at some of their more popular packages and the respective costs of each. For most, the magic number is 1,000 hp. For whatever reason, there is something particularly appealing about achieving four digit power levels. The truth is, making 1,000 hp with a turbo can be done quite cost effectively using off-the-shelf components. We won't leave it at that however, we'll also look at some of the more exotic single and twin turbo combinations capable of making 2,000 and 3,000 hp!

If one can make an honest 1,000 hp and put it in a 3,200 lb car, you can be assured high eight second et's, provided you have the drivetrain and suspension to back it up. If you can find an engine that can make 400 hp on its own, achieving 1,000 hp with boost will be a walk in the park. However, just because your engine will move enough air under boost to reach the 4-digit zone that doesn't mean it will live under the increased cylinder pressures which result under boost. If you are building a big-block, a factory 1053 steel crank and a good set of aftermarket rods will generally get the job done. For a small-block, a 4340



Intercooling practices Rod Short, Precision Turbo

Though there are differing schools of thought regarding the matter, Rod Short at PTE gave us his take on the popular practices for operation of air-to-water intercoolers. For the most part, Rod and the crew at Precision have found that the benefits of intercooling begin to diminish as charge air temperatures are reduced below 90-100 degrees. This however is a generality as Short pointed out that a number of very competitive combinations are actually running inlet temps much below this. This is believed in large part to be the result of the difficulty in getting the fuel to change state (from liquid to vapor) when in this highly cooled and compressed state. This being the case, Precision has introduced a line on high efficiency, lightweight intercoolers which get the temperatures in this target temperature range and eliminate excess weight of oversized units.

With all of the "hot side" components spec'd out, each of our turbo vendors was also able to give us a heads-up regarding some additional components that we may need to round out our setup.

crank accompanied by a set of H-beam (ie; Manley/Eagle) rods is generally a wise choice. When it comes to pistons, most any forged unit will do, but we have found the SRP pistons from JE and Pro-Tru units from Wiseco to offer a nice balance of reliability and price. As far as block choice, a factory block is ok for a big-block, but questionable for a small-block. On the topic of cylinder heads this is an area where turbos have it all over other power adders. Most any aftermarket aluminum cylinder head will do the job on a big-block. For a small-block a head, which moves at least 280 cfm on the intake side will do nicely. Choosing the correct cylinder head ensures that the turbo will operate at a boost level which produces optimal compressor efficiency. A solid roller cam is the best choice, but not an absolute necessity. It is possible to get the job done with a typical flat tappet (solid or hydraulic) street/strip grind. Much as cylinder head selection will impact the boost level at a given airflow, camshaft selection will do the same. Shortening duration will produce higher boost levels, while designs which hang the valves open longer will cause boost levels to drop. Topping things off, most any single plane manifold capable of keeping up with the heads will generally get the job done.

With a long block built adhering to the above guidelines, you're ready to apply some boost. While choosing a turbo may initially be a bit confusing, a few simple facts can go a long way in getting you pointed in the right direction. The key to determining how much power a turbo will make is determining the maximum airflow in lb/minute, which is readily found on a compressor map. As a rule of thumb, 10 lb/min of air will support 100 hp. That being the case, our 1,000 hp application will have us in search of a turbo which moves at least 100 lb/min. When determining the appropriate exhaust turbine, exhaust housings having a lower A/R will spool the turbo more quickly but will limit peak airflows, while housings with higher A/R values will support greater peak airflow values at the expense of low-end boost and low rpm spooling. When it comes to selecting a turbo, Turbonetics has done much of the legwork in publishing their turbo selector matrix, which may be found at <http://www.turbonetics.com/turbomatrix.htm>. We have found this to be a handy tool that permits one to quickly hone in on the right turbo for a given application. Looking at the Turbonetics matrix suggests that we use one of their 76mm Super T Series units equipped with a .96A/R turbine housing or, if we wish to leave some room to grow, one of their 80mm Y2K units.



► For smaller applications (up to 900hp) Innovative offers these 42mm Progate wastegates. For larger applications (1500+ hp), their 51mm Indygates get the job done.

Got Boost?

MILD TO WILD TURBO COMBOS

To get in the ballpark, Precision Turbo suggested that we go with one of their PT88 units equipped with a .96 A/R tangential exhaust housing which would get us in the 1,000 hp zone with possibly a couple hundred hp worth of airflow to spare. Of course they also point out, it's not nearly as easy as all of this sounds. There are a ton of variables which need to be considered such as engine size, induction system, what type of fuel you're using, transmission, and how much boost you throw at it. But generally speaking, this will get you close.

Ola Lysenstoen from Innovative felt that an 88mm single would do the job, but might prove more difficult to interface than a pair of the T4-based units coupled with a pair of cast manifolds also available from Innovative. According to Lysenstoen, this setup is known as their "basic kit" and includes a pair of manifolds, two wastegates and a pair of T4 small frame turbos capable of flowing 55 lb/min each and retails for \$3,995. He also noted that this kit could be upgraded to include a pair of their F2 ball bearing equipped turbos for an additional fee.

Rick Head, president of the recently formed Exile Turbo, suggested that we go with a pair of Garrett GT3582R dual ball bearing turbochargers, 61 MM inducer units capable of supporting 600 HP apiece. "The GT3582R will provide excellent transient response, they are fairly compact, easy to package and are a cost effective ball bearing turbocharger," said Head. He felt that a 360 cubic-inch engine would be plenty to push a pair of these units and that a basic 1-3/4" header would get the job done. He also offered the following advice regarding the hot side components: "Merge collectors are not necessary, however a fabricated collector is

► Based on Garrett's popular frame, Precision Turbo's PT88 is an economical on-ramp to the world of turbocharging. This unit, equipped with .96 A/R tangential inlet turbine will get you some 4 digit power levels in a variety of applications.



Turbocharging Go-To's: Forced Induction Rules of Thumb Tyler Tanaka, Turbonetics

There are very few things that you can count on in racing but I would like to share two things that you can use in your quest for more turbocharging power, whether on the street or the track. And remember, these are just great guidelines to start with on your way to making and breaking records on the race track.

Knowing What Compressor Wheel to Start With

One of the most difficult things is selecting the right compressor wheel size, but there is a great rule of thumb that can be applied when looking at different wheels and their compressor maps. For street applications it is always best to use 9-10 HP for every 1 lbs. of air flowed per minute. This means that if you need to make 1000 HP then you had better start looking at maps that efficiently flow at least 100 lbs./min of airflow at your planned maximum boost pressure. For race cars things can get a little more complicated because of the high volumetric efficiencies they can reach, as well as the use of alcohol based alternative fuels. For these instances it is not uncommon to use 10-12 HP per pound of air. If Methanol is used over gasoline then it is also necessary to calculate an additional percentage increase in power because of the added capabilities of the fuel itself so do not forget to add that into your numbers.

The Power Potentials of Intercooling

The other great constant factor that can be used for determining power is the intake charge air temperature. When it comes to intercooling, bigger is most often times better. Especially when using liquid to air units and reservoirs. The basic formula for dropping temps and increasing power is that for every 10 degrees F that the intake temps can be dropped, 1% in power can be realized. This may not seem like much, until you think that common non-intercooled systems can reach over 250 degrees quite easily. With custom race liquid to air intercoolers from Sparco, those same charge air temps can be dramatically reduced. Intake temps under 100 degrees is in fact the norm not the exception. Could you use another 20% in power potential on your forced induction system? Intercooling is well worth the cost outlay compared to the power and tuning benefits of lower and constant intake temps.



Each of our turbo vendors were also able to give us a heads-up regarding some additional components that we may need.

recommended over a formed collector. The collector is a high-pressure area and a formed collector will just blow up like a 'Satsuma plumb'. It is essential that the weight of the turbo or turbos is supported by brackets and not the header itself. Flipping a set of 'shorty' headers will not last long as they were not designed for the kind of temperatures and pressures of a turbo system," Head added.

In addition to determining the best turbo fit for our 1,000 hp target, one must also get a wastegate capable of scrubbing off enough boost to meet the needs of your application. Selecting a wastegate too small will make it difficult to keep the boost down to manageable levels while also putting you at risk of

overspeeding the turbocharger at high rpm. For an application such as our 1,000 hp combo, Precision Turbo suggests a single 60mm TiAl unit and spring, one for pump gas duty and another for race gas. For Innovative's basic twin kit, Lysenstoen suggested a pair of Innovative racegates, for the 88mm single he felt that one of their Indygates would be up to the task. Head at Exile recommended a pair of 44mm TiAl units for his combo.

With all of the "hot side" components spec'd out, each of our turbo vendors were also able to give us a heads-up regarding some additional components that we may need to round out our setup. Precision Turbo felt that one could get by without an

Got Boost?

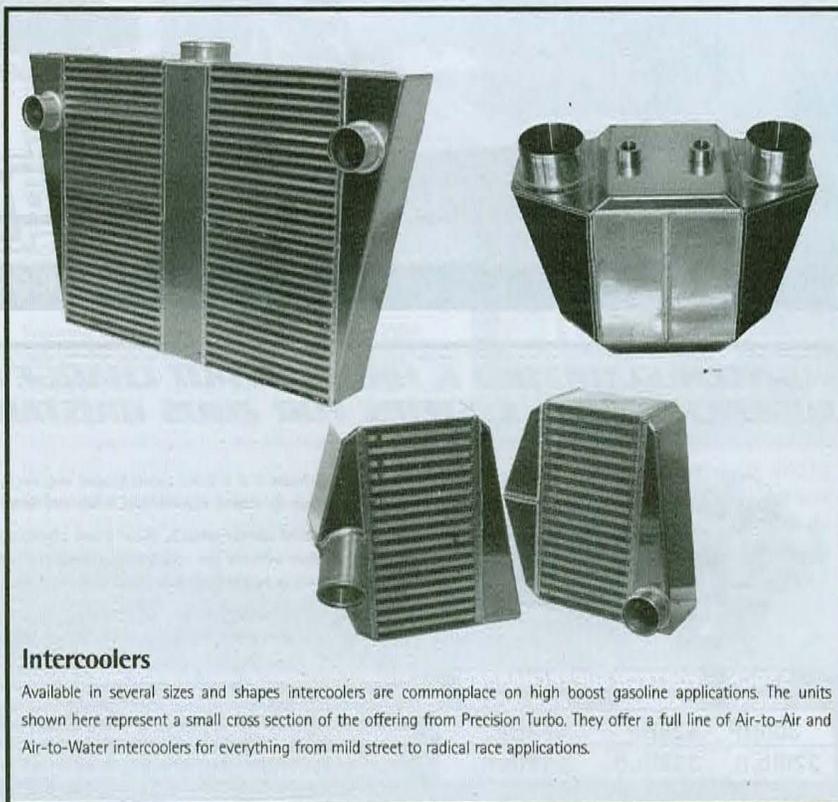
MILD TO WILD TURBO COMBOS

intercooler, but strongly believed that one of their air-to-air units would greatly enhance even the most basic turbo install. With a wide variety of core designs available, Precision can readily fabricate an intercooler to cleanly interface most any application. Rod advised that while there are many low buck imports available, a premium quality bar and plate type cooler such as the units offered by Precision offer superior durability and effectiveness, particularly at higher boost and flow levels. Head at Exile advised that "a TIAI 50MM Blow off valve at the carb hat would be a wise addition" as well. Lysenstoen from Innovative noted that they provide an inexpensive manual boost controller, which retails for \$129, as well as a full-featured electronic multi stage controller (The MSBC-1) which retails for \$749. Exile offers their version of the MSBC-1 as well.

1600-2000HP

While cracking the 2,000 hp barrier isn't for the faint of heart, such combos are becoming more common in True 10.5 and Drag Radial cars. At this power level, high-end engine components are a must. While premium parts (aftermarket blocks, canted valve heads, etc.) are the norm, necessary engine displacements are not terribly difficult to achieve. With the exception of camshaft and compression ratio (unless running Methanol) these pieces differ little from Nitrous engines making 1,200-1,400 hp. Often times these combos can be put together using NASCAR small-block take-off parts such as crankshafts, blocks and near complete top ends including heads, rockers arms and intake manifolds. With a potent 360-400 cubic-inch long block to build

► Innovative's choice for a 2,000 hp small-block, a pair of their F280 units (shown here) are built upon the 80/R aero-combination that have set numerous records over the past few years.



Intercoolers

Available in several sizes and shapes intercoolers are commonplace on high boost gasoline applications. The units shown here represent a small cross section of the offering from Precision Turbo. They offer a full line of Air-to-Air and Air-to-Water intercoolers for everything from mild street to radical race applications.

While premium parts (aftermarket blocks, canted valve heads, etc.) are the norm, necessary engine displacements are not terribly difficult to achieve.

upon, one can quite readily break 1,800 hp and reach 2,000 with a few more psi of boost dialed in. As in our first example, Precision Turbo first pointed to a single turbo, this time one of their large frame 101-115mm turbos. These new 114 and 115mm units are capable of generating an additional boost. The 114 will produce another 6-7 lbs of boost over the 106 mm turbo on a typical small-block application while the 115 with the billet compressor wheel will provide another 6-7 lbs on top of that. A quick perusal of the Turbonetics matrix points us to one their 106 mm "Super Thumper" large frame units. Putting in his two cents, Lysenstoen from Innovative shied away from the big singles and advised that we go with a pair of their F280R turbos. According to Ola: "These turbos utilize Innovative's new F2 dual ball bearing system and feature their 80mm inducer compressor wheel and exclusive R-trim turbine wheel. These new F2 turbos build upon the 80/R aero-combination that

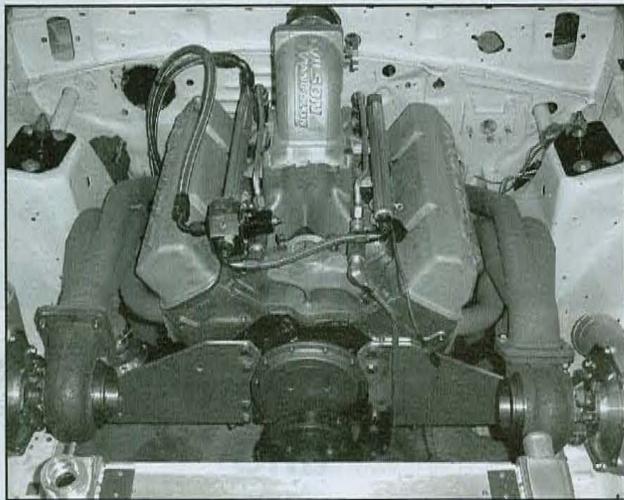
have set numerous records over the past few years." When Rick Head was queried as to his opinion on the matter, he recommended Garrett GT4508R dual ball bearing turbos. According to Head, these dual ball bearing units are capable of supporting 1,100 apiece and offer excellent transient (spooling) response. Our experts agreed that this application would necessitate the use of Methanol or an air-water intercooler. Head also pointed out that if using an electronic boost controller, one would need multiple increase/decrease solenoids to provide optimal boost/wastegate response.

2500-3000HP

Once territory of blown alcohol Pro Mods and the like, recent advances in technology have pushed turbocharged entries into the 3,000 hp zone. Though these combos may be fewer and farther between, "big" (600+) inch turbo engines are gaining

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MILD TO WILD TURBO COMBOS



► Wearing the headers we built in the March issue of FSC, this 18 degree headed small-block Chevy is gearing up to do battle in limited 10.5 competition. The turbos shown here, 76mm units, capable of 1000+ hp apiece, from Precision turbo offer great bang for the buck, retailing for just under \$3300 for the pair.

acceptance in the Outlaw 10.5 and Outlaw Pro Mod ranks. Some of the more highly publicized examples would be the big-block engines found in the Outlaw 10.5 rides of Brad Brand and Tim Lynch (Outlaw 10.5 world record holder, running 6.66 at 223 mph at the 2006 "Shakedown at E-town"). With an engine capable of producing 1,000 plus hp less boost, teams are able to leave on little more than motor, letting the turbos loose downtrack. This minimizes headaches at the tree where some racers like to play games with turbo racers who may need a spare moment or two to get the turbo(s) spooled. These big engines also permit use of lesser boost when compared to small-blocks, partially because the engines are so much larger to begin with, and because they are, twin turbos usually are preferred since they get more air volume into the much larger cylinder bore. With one of these powerplants, aside from icing the intercooler and adding fuel, between rounds

Get in the Ballpark Buying Power

	Innovative	Turbonetics	Precision	Exile
1000hp combo				
Turbo(s)	2 x T4	Super T-76 (Small Frame)	PT-88	2 x GT-3582-61mm
Wastegate(s)	MiniGate	Racegate	TIAI 46	TIAI 41 x 2
Turbo/Wastegate	\$3995, Includes Manifolds	\$3,207.07	\$2,168.00	\$4,268.00
2000hp				
Turbo(s)	2 x F280R	Thumper - 106mm	PT106 (journal brg)	GT4508R
Wastegate(s)	ProGate x 2	NewGen HP	HKS GT II	TIAI 46 x 2
Turbo/Wastegate	\$6,588.00	\$5,184.10	\$3,248.99	\$7,480.00
3000hp				
Turbo(s)	GTB91LW	Thumper-SC 91mm	GT-5591	GT-4718
Wastegate(s)	Indygate x 2	RaceGate x 2	HKS GT II x 2	TIAI 60 x 2
Turbo/Wastegate	\$8,488	\$9,486.80	call	call

* All prices shown are MSRP, typical "street/dealer" prices will vary. Also note that these are generic combos. Each of our participating vendors offers single and twin turbo setups well suited for each of the above applications.

Once territory of blown alcohol Pro Mods and the like, recent advances in technology have pushed turbocharged entries into the 3,000 hp zone.

maintenance is virtually non-existent. One might opt to change an occasional set of plugs for good measure however...While such a combo may necessitate a pricey pile of hardware, when one does the math on the alternatives (piston swaps, blower belts/pulleys, bottle refills, etc...) the long term costs can quickly offset the short-term hit of building such a combo. For this power level, it was unanimous that a pair of large frame turbos would be needed to get the job done. While most racers interested in building these engines are starting from the ground up, it seems that a savvy racer could piece together a potent yet relatively economical combo using some readily available blown Alcohol funny car/dragster hand-me-downs.

As far as preferred hardware, Head recommended Garrett GT4718 dual ball bearing 88 mm turbos. According to Head, these units are "capable of supporting 1,400 HP each. Dual ball bearings and state-of-the-art aerodynamics makes these turbos a

good choice for clutch or automatic applications." Our conversations with Precision pointed us to a pair of PTE prepped Garrett 5591 units for big-inch applications. According to the guys at PTE, they have yet to get a call from a racer using a pair of 5591's calling back in search of more. Innovative advised trying a pair of their GTB91LW turbos, which according to Ola are the lightest weight, large frame turbochargers available and are capable of 1,400 HP apiece. A look at the Turbonetics matrix would imply that a pair of 91mm Thumper S.C. units be employed.

Whatever your needs, each of our experts would be glad to offer you their expertise regarding your combination. With the assortment of digital ignition systems, blow through carburetors and engine management systems on the market today, turbocharging has never been easier or more economical. If you're on the fence, we encourage you to give them a call and explore your options. ■

S O U R C E

Garrett Turbo by Honewell
garrett.gearhead@honeywell.com
www.turbobygarrett.com

Exile Turbo Systems
805.432.5582
www.exileturbo.com

Innovative Turbo Systems
805.526.5400
www.innovativeturbo.com

Precision Turbo and Engine
219.996.7832
www.precisionturbo.net

Turbonetics Turbochargers
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