Tiger Engine Rebuild
Project 260

by **Ken Mattice**

Project Summary

In recent times there has been renewed and building interest in stock and lightly personalized Tigers. I began thinking about a 260 rebuild that plays into this scenario. Namely, a 260 rebuild that is completely stock on the outside with some thoughtful professional blueprinting on the inside. Put another way, I wondered if it was possible to raise the 260 from 164 horsepower to 200 horsepower (25% increase). All the while, ensuring the motor retained good docile drive-ability and zero cooling issues. Thus, Project 260 was born.

Block Preparation

Part Description	Part #	Casting Code	Date Translation
Engine Block In Car	C4OE – 615B	4C -30	Mar 30, 1964
Spare Engine Rebuild	C4OE – 615B	4B - 21	Feb 21, 1964

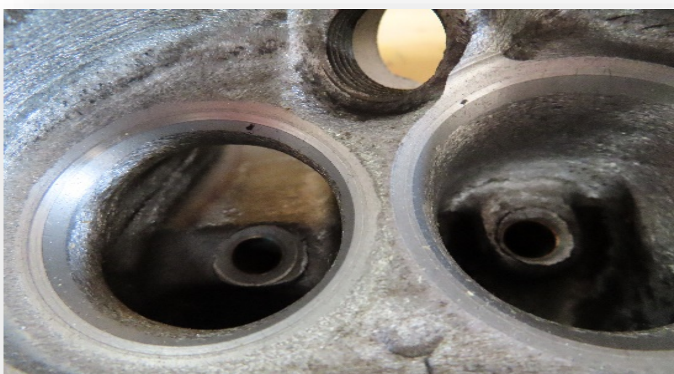
No Tiger engine build will be successful unless you can get the inside cooling passages totally clean. And that's harder than ever, with the passing of 60 years of alternate use and storage. Apparently, hot tanks disappeared 20 years ago, so a different approach was required. The bare block was taken to City Motor Supply, in Dallas, Texas. The freeze plugs were removed, and the block was then furnace baked at 550^{o} F for three (3) hours. After cooling, the block was externally media blasted. Specially shaped blasting tips were used to get into all the internal water passages through the freeze plug holes. The block was then pressure washed with a hot detergent solution and dried with compressed air. Finally, the block was immersed in a liquid anti-corrosion solution, and then strapped back on its pallet and left to air dry.

The block was then returned to Horsepower Research in McKinney, Texas for a meticulous clean out tapping of all bolt holes. A torque plate was then bolted to the deck and the block bored. A Sunnen Hone machine finished the bore to 3.820" and the desired finish put on the cylinder walls. The block was put in the Sonic hot water detergent cleaning machine for 4 hours. Then, it was turned upside down and given another 4 hours. Lastly, the block was dried and then given a liberal dose of anti-corrosion product and bagged, awaiting assembly.

Cylinder Heads & Intake Manifold

Similarly, the heads and manifold were badly corroded and very dirty. All the head and manifold work was going to be performed by Brzezinski Racing in Pewaukee, Wisconsin. Brezezinski is a cast iron engine specialist and is widely thought to produce the best circle track formula engines in the country. Because they work on the old cast iron stuff, they have a license and a facility for acid dipping and cleaning parts externally and internally. So, we packed the parts off to them in their proprietary double walled cardboard boxes They claim to make the parts as clean internally as when they were brand new. Guaranteed!

After reviewing the extremely detailed engine plan questionnaire BR decided upon their SST-289 Stage 1 program for the cylinder heads. BR's extensive data base indicated the 260 ports are already large enough for a modified street engine, so they did not want to make the ports larger. They did, however, CNC port making all ports equal size and shape, and removing bumps and irregularities.



Substantial "bowl work" was done under the valves. The heads were machined for 3/8" screw in studs and new bronze valve guides were installed. Guide plates were installed for 5/16 push rods. Intake valve seats were machined for Farrea 1.782" Intake Valves. The exhaust valve seats were machined for Manley 1.500" Exhaust Valves. Aside from larger valves, these modern performance valves offer much improved flow over 60-year-old OEM valves, given the same size. The flow bench noted the following improvement:

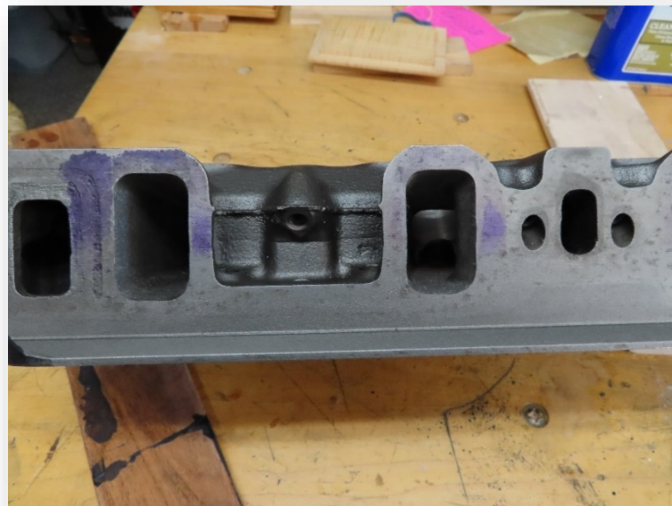
Flow Bench Data

	CFM	CFM	CFM	CFM
Lift	Stock Exhaust	New Exhaust	Stock Intake	New Intake
.100	23	45	40	53
.200	56	66	93	104
.300	100	113	140	151
.400	118	123	142	152
.500	123	125	146	155

Valve Size Comparison

	Stock	New
Intake Valve	1.590”	1.782”
Exhaust Valve	1.390”	1.500”

The intake and exhaust manifolds received the same BR acid cleaning treatment, followed with BR Stage 1 modifications. They even removed the intake manifold sheet metal carburetor heat barrier shield, to make sure it was clean underneath.

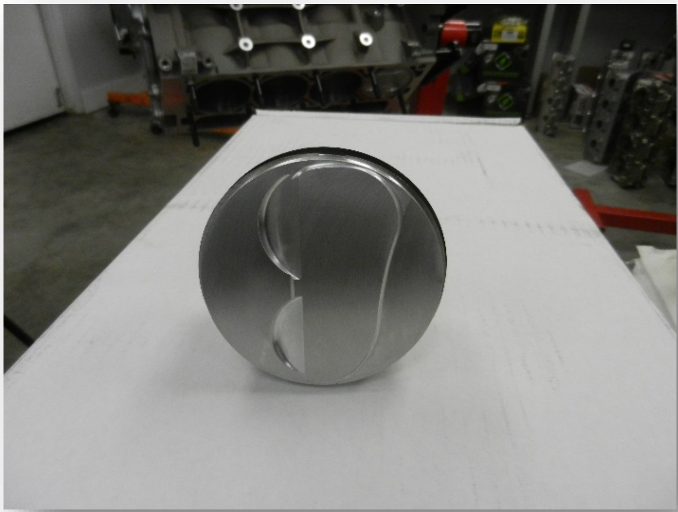


Exterior surfaces of the block, cylinder heads, and exhaust manifold were painted with Thurmalox. This product is a satin black silicone-based coating for extreme heat environments such as turbines and wood stoves. The intake manifold was painted with Dupli Color semi-gloss black engine enamel.

Looking Good!

Pistons

New forged pistons were designed by Eric Koenig at Horsepower Research specifically for this project. This piston allowed us to raise the compression ratio from a stock 8.6 CR to 9.4 CR. The design reduced weight from approximately 800 grams stock, to exactly 415 grams. Modern thin, low drag rings were specified.



Eric states that a 260/289 short block, as built OEM back in the day, took 85-90 foot-pounds of torque to rotate. This 260 assembly, when finished, will only require 30-35 foot pounds of torque to rotate it. Less friction may even produce a slight cooling benefit as well.

Connecting Rods

Eric, at Horsepower Research suggested we use the SCAT I-Beam rod with ARP 3/8” 12 point hardened cap screws. This is Part # 25400927. Because we wanted to flatten and fatten the torque curve the 5.400” long rod was selected compared to the stock rod of 5.154” center to center length.

For some time it has not been economically feasible to rebuild stock connecting rods. Plus, when you are finished you end up with an inferior part.

Crankshaft

The stock crankshaft was sent out to a crank grinder in Dallas, where it was checked for straightness, magnafluxed, and ground .010” under size. It was then polished. At our intended power and RPM levels it did not make economic sense to purchase an after-market performance crankshaft.

Camshaft

The camshaft is the heart and soul of the motor, and largely determines whether you will meet your project goals. I chose to work with Bullet Racing Cams, a custom cam grinder in Memphis, Tennessee. BRC has an even more exhaustive questionnaire regarding the car, intended usage, and the project goals than does Brezezinski Racing.

The first question on the table, is whether to choose a hydraulic roller lifter cam or a hydraulic flat tappet cam. Rollers have more area under the curve, and even with very modest cam specs, provide a definite benefit in performance. Mark Chacon at Bullet Racing spent a lot of time comparing his data base to the questionnaire and to the Brezezinski questionnaire. As you can see in the cam table it is quite a modest cam, but substantially more aggressive than the stock cam which is almost not a cam.

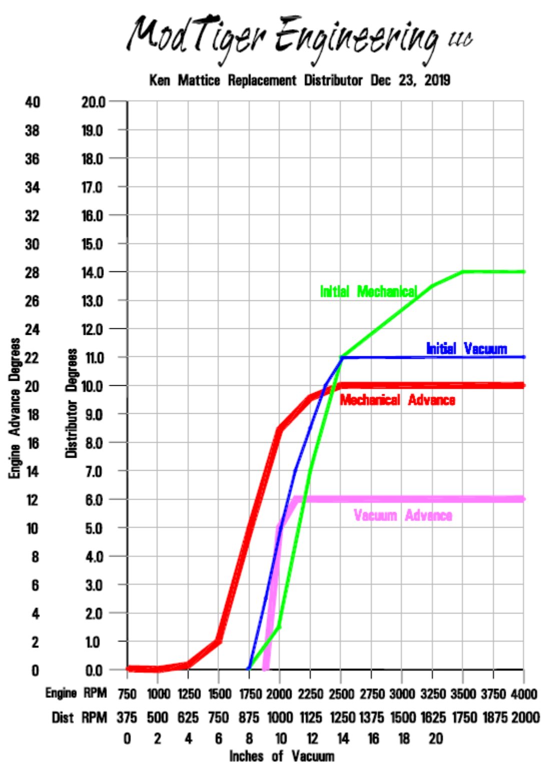
The intention is to dyno this motor when finished and it will be interesting to note how this cam performs against our goals, modest as they are. The roller cam costs $1200 and the flat tappet costs $600, but I think the roller will prove to be “worth it”.
The actual Bullet assigned part # for this cam is FB 264/268 H108+4. The hydraulic roller lifter’s part # is LRR-5323. The intake opens at 2, closes at 30. The exhaust opens at 40, closes at -4. As a compliment to the cam, Comp Cams roller tip rockers # 1442-16 were selected because they are low profile and non-rail style. Steel 10° retainers and locks rounded out the package. Firing order remains 15426378.

	.050	**.050**				
	Duration	Duration	Lift	Lift	CL	CL
	Stock	Bullet	Stock	Bullet	Stock	Bullet
Intake	184°	212°	368”	.525”	109°	108°+4°Adv
Exhaust	189°	216°	380”	.525”		

Distributor

The early Tiger OEM distributor was sent to Tom Hall at Mod Tiger Engineering for rebuild and modification. It soon became clear that a total rebuild was required as the unit had a lot of time and miles. All the wearing components were replaced including a new vacuum advance module. Tom added a Pertronix unit for reliability. He then installed a new steel gear, for compatibility with the roller cam.

When it was back together and working properly Tom set it up in his distributor machine. He recorded initial stock mechanical and vacuum advance curves. Too slow!



So, he set about building new curves. It is now much quicker. All in by 2,500 RPM, producing total engine advance of 20 degrees. We will set the initial engine advance at the crank at 10 degrees, so we will get a total of 30 degrees. The cam builder was very approving of the new advance curves. See the graph provided by Mod Tiger Engineering.

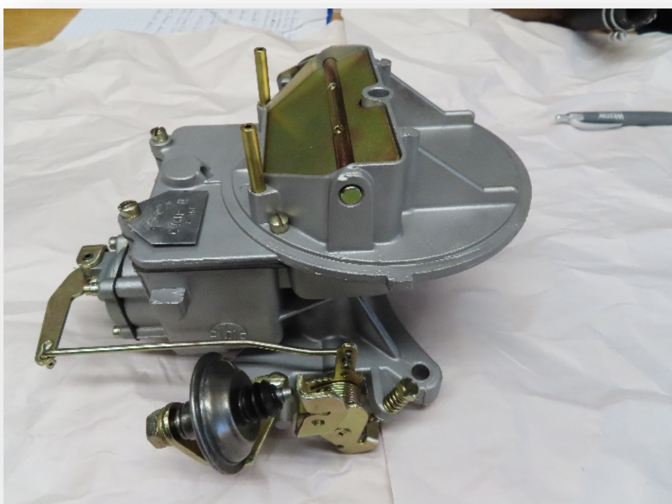
Water Pump

In keeping with our mandate of a totally stock visual, we opted for a NOS C40E-8505 – A water pump. I contacted Flow Kooler in Paso Robles, CA for an improved one – off water flow solution. They agreed to retrofit their curved vane, high flow impeller to the stock water pump. Flow Kooler's impeller part # is 168. Flow Kooler claims an 18% increase in flow volume over the stock pump. The water pump pulley utilizes the so called "Fairmont Ratio", driving the water pump and the engine fan 12% faster than stock. Being that the pulley is a slightly smaller cone size, requires trimming/ filing the external vanes on the stock pump casting, to allow the pulley to fit over it.

Normally, we would install a Stewart 160^{o} thermostat with (3) 3/16" holes drilled in the body to divert water to the bypass. However, the dyno guy asked us to leave it out, as the dyno controls the engine temperature, without interference from the thermostat.
Similarly, the dyno does not want the engine assembled with an on-board starter. The dyno starts and stops the engine.

Carburetor

The Tiger 260 came equipped with an Autolite 2100 series two-barrel carburetor. There were 8 carbs in the 2100 series, ranging from 190 CFM to 424 CFM. Specifically, our OEM Tiger model 1.01 flowed 240 CFM. The 1.01 is a reference to the venturi diameter. The model 1.14 flows 300 CFM, and was commonly found on 352's. The bore size for both models is the same at 1.4375", only the venturi plate is different at 1.23". The good news is that the venturi plates are completely interchangeable, as are all the small bits of external hardware.



Carolina Carburetor in Wilmington, South Carolina rebuilt the Tiger core using the larger 1.14" venturis, and upped the primary jets from #44 to #54. The overall result is a 40% increase in CFM flow, which the new engine can no doubt take advantage of. Once assembled, the carb was fine-tuned on a Pacco Flow Bench Testing machine. There are no outward visible changes in the carburetor, which fits in with one of our major design parameters.

The dyno will tell us if this was a good choice!

Miscellaneous Musings

- The Damper Doctor in Redding, CA rebuilt the stock harmonic balancer.
- A Cloyes street billet true roller timing chain and sprocket set, part # 9-3535X9 was selected.
- Because we won't be seeing any RPM north of 5,500 RPM we opted for a stock volume, stock pressure oil pump from Mellings, part # 10687.
- The stock 28 oz. imbalance flywheel was cleaned and surfaced.
- Connecting the water pump to the lower crank pulley without the generator required a special Gates fan belt # XPZ762, purchased from McMaster-Carr. Thanks to Bill Martin at Rootes Group Depot for supplying the correct belt length. The belt is 762MM or 30.00" in circumference.
- Scott Drake reproduction chrome valve covers with the correct stickers will be installed, along with Felpro # 1645 Double Thickness gaskets, for rocker arm clearance.
- A Wix Oil Filter #51515 will be screwed onto the block for dyno purposes. This requires sourcing the Ford Oil Filter Adaptor Bolt part # C20Z-690-C, which Tiger blocks did not originally have.
- The original 2-pc rear main seal that the 260 utilized, will be replaced with a Fel-Pro or Cometic 2-pc Viton, low drag seal. The Viton seals are far superior to the old "rope" seals these engines came with from the factory.
- A derelict Tiger Air Cleaner was sourced from Bill Martin at Rootes Group Depot. It had corrosion, holes, and flaking chrome plating. Two different artisans brought it back to life, including correct paint. It will be run on the dyno with a K&N Air Filter Element.
- A Ford Performance Steel Cam Retention plate #M6269-A351 was sourced to match the steel roller cam.

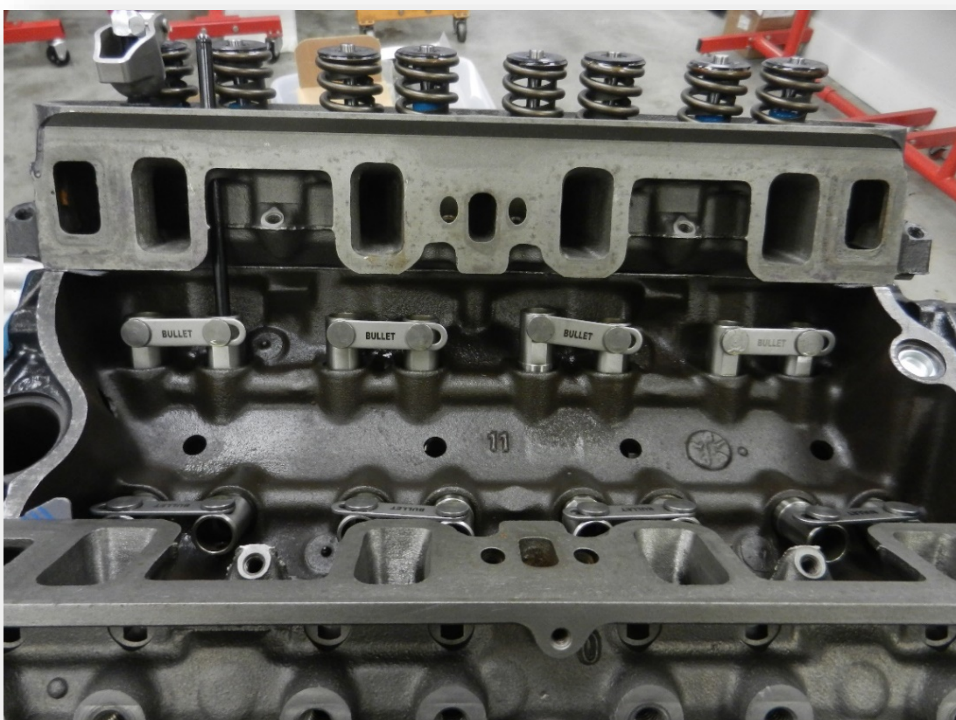
Assembling the Cylinder Heads

A single valve spring # VS 126 was selected to match the cam and to fit the stock one inch "stepped" valve spring seat cast into the cylinder head. Corresponding 10^{o} Steel Retainers and Steel Valve Locks were used, part #BSR740 and #BUL610. The springs were designed to be installed at 1.900" +- .005". Achieving this installed height required a .060"shim in the spring seat. This setup, gave us a closed spring pressure of 115 ft. lbs. and an "over the nose" pressure of 275 ft. lbs. That is cam guy talk for an open valve!

Pretty blue valve stem seals are shown in the picture as installed.

Engine Assembly

The front of the engine begins to take shape with the fitment of the front cover, water pump and the two drive pulleys. Note the screw on oil filter. This was required because the Dyno Guy won't allow home made remote filter setups in his dyno cell. Apparently, over the years he has had a few of them come apart, creating a mess. After the dyno session, this filter setup will be removed and replaced with the stock Tiger remote setup.

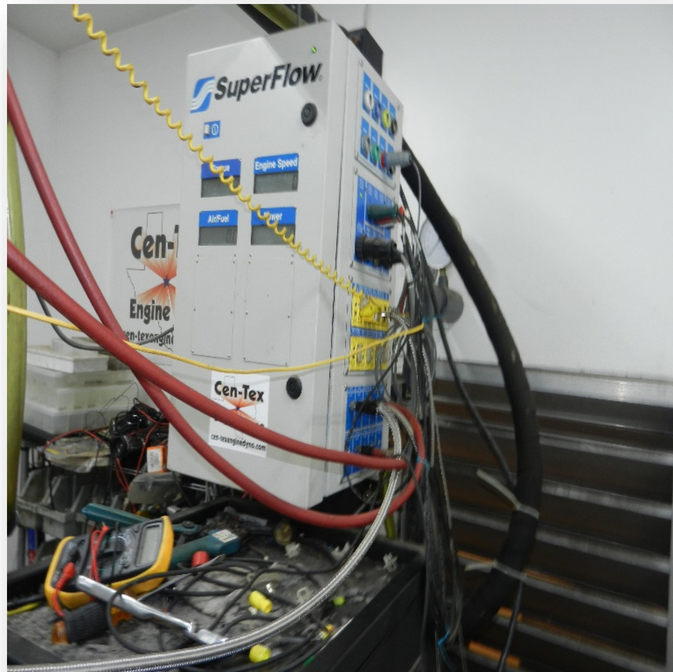


Fast Forward to Final Assembly

The last significant internal assembly usually involves getting the rocker arm geometry just right. Four different length pushrods were ordered, and thru trial and error one was deemed the correct length, and a full set ordered. Once the rocker arms went on, the hydraulic roller lifters were adjusted. Finally, on went the intake manifold and carb. Time for the stock reproduction valve covers from Scott Drake, utilizing the extra thick cork and composite Felpro valve cover gasket # 1645. The rocker arms did not hit the oil control baffle in the left valve cover. The generator bracket was installed simply to allow the dipstick assembly to be fastened in place. The generator itself, was left off for the dyno session.

Next Stop
Centex Engine Dyno
Killeen, Texas

We contacted Joe Nunke, the owner operator of Centex Engine Dyno in Killeen, Texas. For you civilians out there, Killeen is next door to the massive Army base known as Fort Hood. Centex operates a DTS Powermark Dyno that replaced the Superflow 901 after DTS bought Superflow.



Dyno Control Center

Once arrived, we encountered the first problem. No one dynos 5-bolt small block Fords, so there was no ready-made solution to hook the 260 to the dyno. Joe had to engineer a custom-made solution, which he did. It did not take long to find the second speed bump. Even though we had increased the carb jets from 44 to 54, it was far too lean. The engine ultimately wanted #61 jets. We didn't have any larger jets, so the testing was paused, as a super lean condition or a super-rich condition will just not allow the engine to rev thru the mid-range. The fuel curve has to be somewhat close, to even do the testing.

Armed with every jet ever made we scheduled another test session. This time we got the Fuel Curve nailed down sufficiently for further testing. I won't personally install any newly built engine in a Tiger without dyno testing to find any leaks, tuning issues, or even more serious flaws in the build.

Having gotten the mixture correct we now started to see how much timing the engine wanted. We started at a total of 30^{o} and wound up at a total of 34^{o}, before losing further benefit. So, now we are close enough to start testing the engine for horsepower and torque, through the mid-range and the intended maximum of 4,500 RPM.

Side View Engine on Dyno

What happened next, is exactly why you go to the Dyno, before installing the engine in a Tiger. At 4,000 RPM we start encountering valve float, preventing completion of the test. Valve Float can only mean we have the wrong springs for the cam profile, or we have issues with the install height and shimming for the correct seat pressure. Well, Damm! But better to find out now and not later.

Fortunately, and coincidently, one of the finest automotive machine shops and engine builders in Texas is located within a couple miles of Centex. A call was made to Darren Hosman the owner of Hosman Machine Shop and he agreed to take on the valve spring problem. So, once again, the engine comes off the dyno and we truck it over to Hosman. Once again, I drive home from Killeen to McKinney, a three-hour drive.

Fast Forward: Darren Hosman checked the installed height and seat pressure of every spring. All the seat pressures were 105# - 110#. Too low for even a modest hydraulic roller cam. Utilizing something called minus 50 valve locks, and different shim packages, Darren was able to achieve the correct installed height of 1.9" and a new spring seat pressure of 140#. Okay, back to Centex Dyno.

Third times the charm ... at least in this case. Warmed the engine up and made our pull. See the dyno sheet pictured below. Well, we made one of our goals, as the engine made 205HP at 4,300 RPM. The torque curve is amazingly flat starting at 274 ft lbs at 3,000 RPM to 243 ft lbs at 4,400 RPM. Max torque was 276 ft lbs at 3,400 RPM. Amazingly, average torque fr4om 3,000 – 4,4400 RPM was 273 ft lbs.!!! This RPM range is the real world a stock street Tiger operates in, especially so, with a 2:88 rear end ratio.

These numbers represent a substantial improvement over original stock and will make for a very, very fun car to drive on the street!! For perspective, a stock original Tiger makes a maximum torque of 258 ft lbs. at 2,200 RPM.

Front View Engine on Dyno

Cen-Tex Engine Dyno

Cen-Tex Engine Dyno
20570 Stillman Valley Rd
Killeen, TX 76542
254 577 2928
www.cen-texenginedyno.com

"corrected power" from test ken_mattice_260_20.sfd

Test Information:
File name: ken_mattice_260_20.sfd (NUNKE_PM.cfa)
Data page: corrected power - 15 lines total
Tested on:

Specifications:
_6_in 0 Yes_No, _9_in 1 Yes_No, Cycle 30 secnds, EngBor 3.820 inches, EngCyc 4 cycles, EngCyl 8 number, EngStr 2.870 inches, FuelSG 0.750 lb/gal, Inrtia 0.550 factor, Kfacto 0.000 TrqMlt, Lower 3,000 rpm, OvrRat 1.000 Ratio, PP_rev 60.000 ratio, Recpcl 60.000 ratio, Return 3,000 rpm, StepTm 4.7 Second, Stoich 14.70 AFR, StpSiz 300.0 rpm, Thrott 0 Yes_No, Upper 4,400 rpm, VPos 0.90 ratio

EngSpd RPM	STPIPw CHp	STPITr Clb-ft	AFR_1L AFR	AFR_2R AFR	Oil_P 0-150p	Fuel1P 0-100p	BSFC lb/hph	CoolOT deg F
3,000**	156.6	274.1	13.44	13.08	56.8	3.7	0.576	153
3,100	161.4	273.4	13.14	12.98	56.9	3.7	0.625	153
3,200	165.8	272.1	13.04	12.89	57.2	3.7	0.631	154
3,300**	172.0	273.7	12.93	12.82	57.5	3.7	0.618	154
3,400	178.8	276.2	12.70	12.71	58.0	3.7	0.601	154
3,500	183.3	275.1	12.56	12.63	58.5	3.7	0.590	154
3,600	186.4	271.9	12.46	12.57	59.0	3.7	0.593	154
3,700	189.8	269.4	12.49	12.54	59.5	3.6	0.599	155
3,800	193.6	267.6	12.56	12.58	60.0	3.6	0.603	155
3,900	197.6	266.1	12.66	12.69	60.6	3.6	0.603	155
4,000	200.1	262.7	12.81	12.68	61.2	3.6	0.605	155
4,100	201.6	258.2	13.00	12.63	61.6	3.6	0.611	155
4,200	203.1	254.0	13.18	12.55	62.0	3.6	0.616	155
4,300	205.1	250.5	13.35	12.56	62.3	3.6	0.616	155
4,400	203.7	243.2	13.56	12.68	62.7	3.6	0.622	156
Avg								
3,150	***163.9***	***273.3***	***13.14***	***12.94***	***57.1***	***3.7***	***0.613***	***153***