

See our  
"Machines that  
Clean" cleaning  
product  
spotlights  
on page 43!

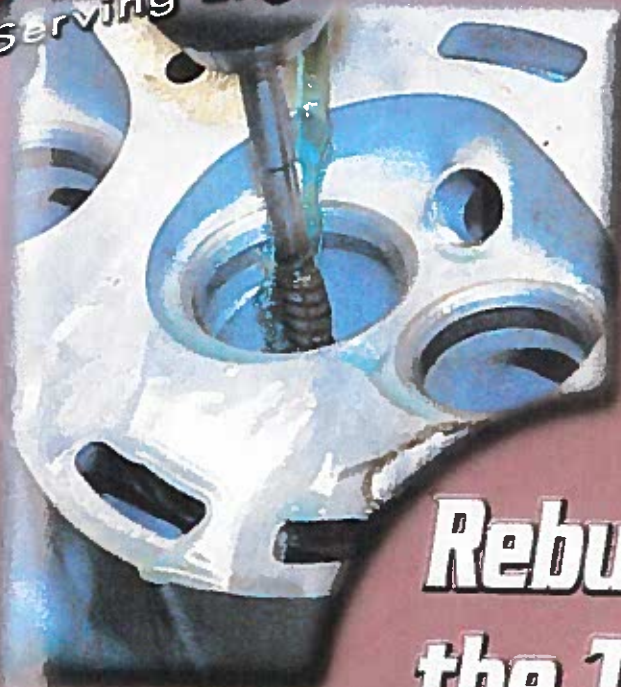
July 2001

Babcox

# ENGINE BUILDER

www.engine-builder.com

Serving Engine Builders and Rebuilders Since 1964



## Rebuilding the Toyota 3.0L V6 50HC Head



Also inside • Media Frenzy: How Shot Blasting Gets Done  
• Machine Shop Market Profile Part 2

# Rebuilding the Toyota 3.0L V6 SOHC Head



By Jim Walbolt  
Contributing Editor  
jwalbolt@babcox.com

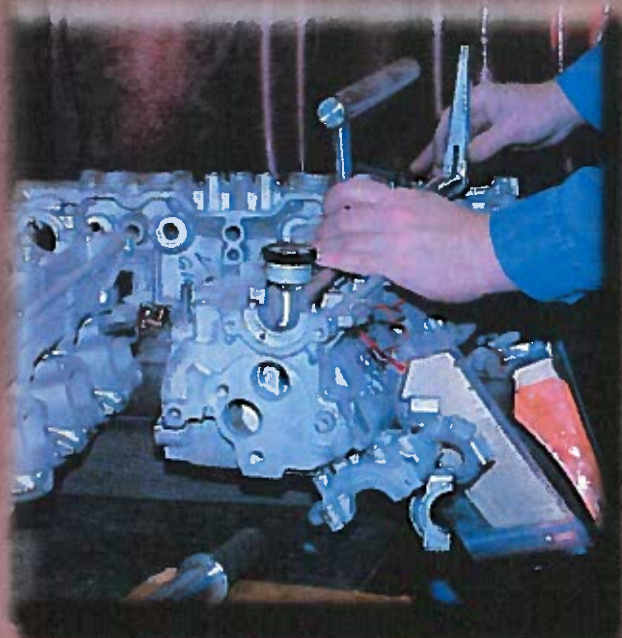
**T**he Toyota 3.0L V6 was introduced in Toyota trucks in 1988 with single overhead cam heads. This engine was designated as the 3VZ-E and was available for the truck line until 1995. This eight-year run means there are literally tens of thousands of these engines and heads out there for remanufacture.

According to Carl Simmonds, production specialist at VEGE Manufacturing, the 3VZ-E SOHC heads are very good heads with very few problem areas. The Toyota cams are particularly good, but only have about .001" hardening and you can't grind them, but that is normally not an issue. For readers unfamiliar with VEGE, the Dutch company owns ATK Industries, and together they constitute the largest remanufacturing business in the world. VEGE and its worldwide rebuilding facilities supply the remanufactured

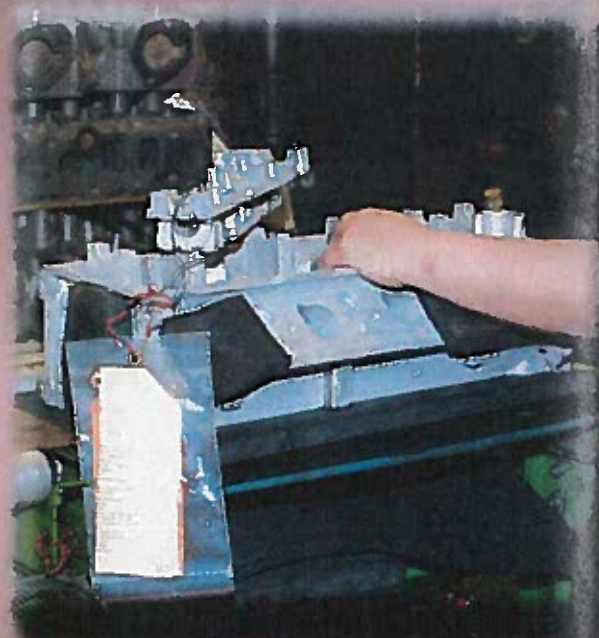
products that ATK markets globally.

Simmonds was kind enough to let us spend a couple of days at VEGE's Falmouth, KY, facility, where we followed the 3VZ-E heads through the facility where they are remanufactured the "VEGE-WAY." VEGE remanufactures hundreds of heads each day so its rebuilders are intimate with any problem areas for the 3VZ-E heads. However, because VEGE has its own proprietary specifications for each step, we will give you the manufacturer's recommended specs as provided by Alldata in most cases.

Of course the first step in any remanufacturing process is disassembly. Whether you're a one-man shop, or a large volume shop, disassembly is as important as reassembly, maybe even more so. This is where you have to decide if the core can be remanufactured. It's important to keep the camshaft bearing caps together with the head they came from. The bore alignments will never be the same on different heads; they will have a different matching pattern. You will save yourself a lot of grief if



*Checking a Toyota 3VZ head cam bore for straightness; .001"-.002" is allowed.*



*Head being vacuum tested before going to stud and bolt repair station.*



*Finishing the valve seats on a Toyota 3VZ head with a Serdi 5.0. VEGE only allows .020" off seats before replacing.*



*Checking the thickness of the head. You need to try to maintain OE specs to maintain compression ratio. With ORD II coming, maintaining OE specs will be critical.*

you mark the caps as to their position as you remove them.

If you find a broken or damaged cap at this time you will need to repair or replace it, and in the case of the 3VZ-E, that means finding one from a scrap head. They cannot be welded and there are none available from aftermarket suppliers. If you are a large volume rebuilder, you probably have a supply from heads that have been scrapped. A small shop that only does a few of these needs to be sure it can find the caps it needs.

When removing the valves, you should note if any are broken or bent. If so, you should check the valve guide closely and remove it at that time, because once the head has gone through the oven, the guides are very difficult to remove.

When VEGE disassembles a head, all the parts and pieces are kept together by engine family, but not for each individual head (except for the cam bearing caps). A shop that only does a few of these heads at a time should keep all the parts together with that

particular head. For instance, keep the lifters and shims in correct order. The same holds true for the valve springs and valves.

As the head is disassembled, you need to remove all the freeze plugs, of course, but the 3VZ-E head also uses steel balls in the oil galleys. VEGE rebuilders use a special arc gun that welds a stud to the balls, and then they use a slide hammer to remove them.

Once everything is removed and you are down to the bare casting, you will need to run it through a washer of some type, because this is where you will find the first of the few problem areas this head has. The 3VZs are terrible for having oil



*On the Toyota 3VZ, dowel pins locate the cam bearing caps at #1 and #5.*

and grease burnt into the interior of the head, and it is very difficult to get them completely clean. At VEGE, these heads are first jet washed in a pulse washer, then are sent to the ovens to be baked.

The heads are baked at 450° F for a six-hour cycle. Although the process could be done at a higher temperature a little quicker, it's important to remember that if you begin to exceed 550° to 600° F, you will put that head into a "soft" condition and that will begin to change the structure of the head. You may end up softening the casting enough that it could cause a problem.

Once the head comes out of the oven, it is glass beaded. Then the head can be further inspected for any needed repairs before the machine work starts. But Simmonds points out that probably 85 percent of the problems VEGE rebuilders uncover are from the handling of the head before it gets to the shop. Of course, VEGE is a large volume shop and the cores come across

country by the thousands. A small shop is probably getting the head straight off the car and most likely won't see any handling problems.

Before the head begins the machining processes, it should be tested for leaks from cracks or pinholes. A dye penetrant such as Goodson's Alumni-Chek or its equivalent can be used to check combustion chambers and intake and exhaust ports, as well as the head surface. However, a vacuum or water test, whatever your shop has available, is the best way to check that the head doesn't need any further repairs. With dyes, you will only find cracks you can see. You don't want to get the head half-finished or worse, completely finished, then find a crack or leak.

The next step at VEGE is stud and thread repair. Each hole is retapped with a burnish tap and any threaded hole that needs repair will get an insert such as a Heli-Coil installed. From there the head is sent to the seat and guide machine. If a cracked or broken guide was discovered during disassembly, it is replaced at this time. According to those we interviewed at VEGE, with the 3VZ head you will usually never find a valve guide that



*Checking the cam housing size after cutting and reinstalling the caps to determine if there is enough material to hone or bore to finished size. Caps can be re-cut if there is not enough clearance.*

needs replaced because of wear, except in a very unusual situation.

Toyota specifies a standard valve stem oil clearance of .0010"-.0024" for the intake and .0012"-.0026" for the exhaust. Checking the inside diameter of the valve guide bushing. Toyota specifies 0.3154"-.03161". The standard valve stem diameter is .3138"-.3144" intake and .3136"-.3142" on the exhaust valves. Use a caliper gauge to check the guide bushing and a micrometer for the valve stem. Maximum oil clearance would be



*Torquing the main bearing caps on cam housing with a size/straightening bar. One bank or side is torqued to align caps, bar is removed, then the rest of the caps are torqued. Cam bore can then be honed or bored as needed.*

0.0039" for the exhaust and 0.0031" for the intake.

Don't fall into the trap of sticking a valve in and wiggling it back and forth with your fingers. I don't know about you, but my fingers aren't calibrated in thousandths. If the clearance exceeds the maximum, the guide bushing will need to be replaced.

When checking your valves, it is a good idea to inspect the valve keepers. While there isn't normally a problem with keeper wear on the 3VZ-E, they can become damaged. At VEGE, a new valve, valve spring and retainer setup is used to check keepers. If the

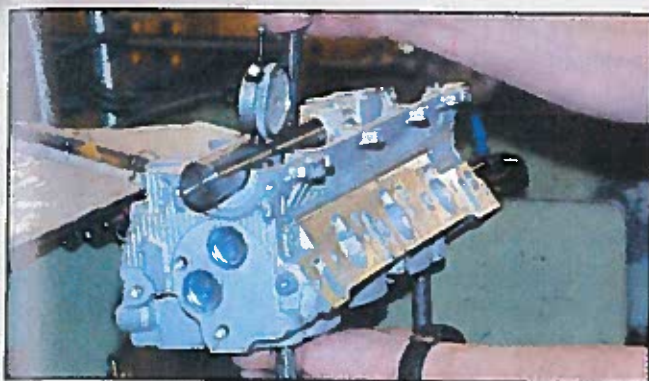
keeper sets too low in the retainer, it's worn and needs to be replaced.

VEGE installs phosphor-bronze valve guide sleeves into the OE guides in every head. A self-lubricating "diamond" pattern valve guide sleeve is used because VEGE has found that these sleeves control oil extremely well. By using the bronze sleeves, it also allows them to use a standard valve stem size for every application, in this case, 8mm. Simmonds has also found that his shop can generally run tighter clearances with these inserts.

Installing bronze sleeves this way

**Return your wash water and chemical  
to the Washer Reservoir, and throw  
your waste into a sanitary landfill.  
[www.martwash.com](http://www.martwash.com)**

Circle 31 for Reader Service



Checking installed valve height. With OBD II it is important to stay within OE specs.



Diamond honing valve guide on a Toyota 3VZ head to remove nicks & burrs. Removes about .001"-.010".

also enables a shop to maintain proper stem to guide clearance through "ball-broaching," even if the valve stems or guides are each worn a little differently. By using a different size ball broach, you can maintain the proper clearance with the same inserts. The carbide balls used for ball broaching are 91 Rockwell hardness and are within 800/1000ths of perfect roundness.

If you need to replace the guide bushing with an OE bushing, you will need to remove the old bushing and measure the bushing bore. If the bore is 0.5118"-0.5129" you can use a standard bushing. If the bore measures 0.5138"-0.5148" then use a 0.05" O/S bushing size. Toyota rec-

ommends replacing the head if the bushing bore exceeds 0.5148".

If you install bronze sleeves you will need to trim them, then deburr them. VEGE gets away from this time consuming process by diamond hon-

going to be machined, the combined amount of material removed cannot exceed this amount (0.010").

Although it's a rarity now, at one time early in its life, this engine suffered from head gasket failure, so



It is important to lubricate the threads as well as the head of all fasteners before torquing down.




Lubrication is very important when reassembling an engine or head. When a newly remanufactured engine is first started it will run dry for several seconds and can cause damage if not properly lubricated during assembly.

ing the guides. The hone is set so that it takes off just 1/10th of a thousandth. This removes any imperfections in the top or bottom of the guide.

You will probably also be milling the head, if, for nothing else, just to make a light cleanup cut. Toyota allows a maximum of 0.0039" warpage on the 3VZ heads. Although Toyota says that if you are less than 0.0039" you can reuse the head without machining, taking all warpage out by milling is just a good practice.

Toyota allows a maximum material removal from the head of 0.010", but if the block and head are both




**Engine Rebuilding Equipment**

*Check out RMC's Cleaning Systems*

**RMC Spray Washers**


- 32" x 24" (SW2)
- 40" x 28" (SW4)
- 54" x 28" (SW5)
- 60" x 36" (SW6)
- Hot tanks std (not SW2)
- Post-gear turntables
- 11 ga. double wall insulated (not on SW2)
- 5 - 15 hp pumps available
- 7,500 or 12,000 watt heaters
- Gas heat (225,000 btu's) available



SW4 shown

**RMC Closed Loop Rinse Booths**

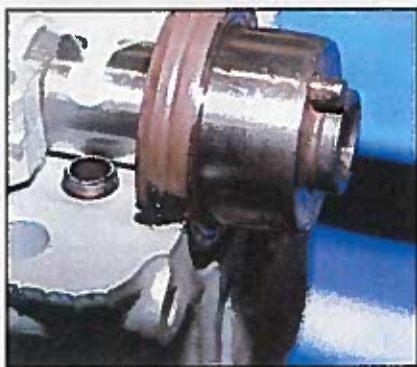
- 48" capacity (RB4)
- 60" capacity (RB5)
- 24" / 28" turntables
- Greaseable bearing
- Less spray-back design
- Space saver - Reclaimer tank fits under the Rinse Booth



RB4 shown

Rogers Machine Company  
 5775 Bridgeview Center  
 Saginaw, Michigan 48604  
**Phone (800) 248-5062**  
 Fax (989) 754-1696  
[www.rmcengine.com](http://www.rmcengine.com)

Circle 35 for Reader Service



On the Toyota 3VZ heads, this point is a common cause of oil leaks. Application of a good sealant when reassembling will prevent future problems.

attention to the head surfaces is important. In late 1994, Toyota addressed the head gasket problem

with a new gasket. The new OE p/n is 11115-65031 for the right side, and p/n 11116-65031 for the left side. Additionally, aftermarket gasket makers have also come out with improved gaskets for the 3VZ.

While we are talking about head surface and gaskets, remember that the finish on the head can be critical. If you are using an OE gasket, you must finish the head at the OE recommended Ra. If you are using an aftermarket gasket you must finish the head to that particular manufacturer's recommended Ra.

The manifold sides of the head should also be checked for warpage. Again, Toyota specifies a maximum warpage of 0.0039". VEGE likes to mill the exhaust and intake sides of these heads regardless of the measurement to take away any question of their condition, and because of damage that may have occurred during handling.

After machining, VEGE checks

the finished thickness of the head using the company's own specs for this measurement. The rebuilder has what it calls a Stage I and a Stage II. A Stage I head will stay within OE specs for compression ratio, etc., while a stage II head needs a head shim to fall within specs. By using a head shim, VEGE is able to save heads that would otherwise need to be scrapped.

The valve seats are finished on a Serdi 5.0. When finishing valve seats or valves, VEGE only allows a total 0.020" combined material removal. VEGE will also finish the seat and valves so that the valve springs will fall into spec with a 0.030" shim. If the springs test to spec with a 0.030" shim they will be used; if not they are scrapped. Remember that grinding the seat and valve will move that valve up in the head and will raise the installed height, thereby taking tension off. Toyota specs call for a

**CWT Industries**  
**Hi-Performance Crankshaft Balancing**

**Multi-Bal 3000**

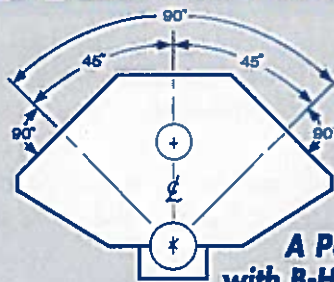
20" Multi-Axis Air-Floating Workhead  
 PRO-FORM II CNC Powered Cylinder Head Machining Center  
 10" X 58" Work Table

1-800-449-1849  
 Raising The Standards Of Industry  
 WWW.CWTINDUSTRIES.COM  
 770-446-1999 Fax 770-446-5727

Circle 20 for Reader Service

## BUILD IT RIGHT WITH B-H-J!

Be a Winner with B-H-J Products' Total Block Preparation System



A Perfect Engine Begins with B-H-J Precision Fixtures!

- "BLOK-TRU" for square decks and exact block height!
- "BOR-TRU" for precise cylinder bore locations!
- "LIFTER-TRU" for perfect lifter bore alignment!
- "DOWEL-TRU" for accurate bellhousing position!
- "HEAD-TRU" for matched head and manifold runners!
- HONING PLATES for round, straight cylinders!

Engine Builders! B-H-J Products is your source for precision automotive fixtures and tools. From ultrasonic cylinder wall thickness testers to piston ring end gap gauges, B-H-J has it all! Send \$2 for new catalog.

B-H-J Products, Inc. Phone: 510-797-6780  
 37530 Enterprise Ct. Fax: 510-797-9364  
 Newark, CA 94560 Web: www.bhjinc.com



Circle 56 for Reader Service



Checking valve lash and installing proper size shims for proper valve lash.

valve spring deviation of 0.0484" maximum. Free length for white painted marked springs is 1.8307" and for the green painted marked springs, 1.8508". Installed tension at 1.575" height is 54.5 - 60.2 ft.lbs.

Proper valve length is also critical for proper installed height and tension. Standard overall valve length is 4.106" while minimum is 4.087". Valve face angle should be 41.5° and margin thickness should be 0.051" - 0.067" with a minimum of 0.039". Remember, we said earlier that the hardness in the Toyota cams is only 0.001" deep. Excessive spring tension will cause premature wear of the cam lobes.

The cam bore needs to be checked with the caps in place. At VEGE, the main caps are torqued with a sized "straightening" bar placed in the bore. One side of the caps is torqued to align the caps, the bar is removed, and then the rest of the caps are torqued. A dial bore gauge is used to check clearances. Journal oil clearance is 0.0010"-0.0026" standard, with 0.0039" maximum. The cam journal needs to be checked with a micrometer to determine if you have proper oil clearance.

According to Simmonds, when assembling these heads, torquing the caps down with a control bar and checking the clearances, you will find they are nearly always outside of the OE spec. This is probably because the caps move around some; and the fact that they are aluminum and they get out of round. At VEGE, rebuilders will trim all the caps, then line bore and/or line hone virtually every cam bore on every head.

If you do decide to trim the caps and hone the cam bore, you need to remove as little material as possible. At VEGE, no more than .001" is ever



Checking a shim for proper size.

removed. The main reason is a fairly simple one. When you hone the bore you lower the cam centerline in the

bore. When you do this, any seals will be in their original position, while the cam will be in a lower position. When you install the seal and torque down the caps and covers, it will press that seal into an egg shape, causing an oil leak. A thousandth or less isn't a problem, but start increasing that and it could become a big problem.

While checking the cam journal, you should also be checking the cam lobe height and cam runout. Lobe height should be 1.8830"-1.8870" with a minimum of 1.8701". Cam runout should be checked at the center journal. Maximum runout would be 0.0024". Again, these cams are generally very good and you shouldn't expect any problems.

The most pronounced problem you will ever find on the 3VZ-E heads will be a spun cam bearing. Because VEGE has the capability of boring the cam bores, damaged cams will be sent out to be chromed to a 0.010" over. That .010" over cam can be used in a head that is damaged beyond VEGE's honing capabilities. This can save both a cam and a head that was damaged that might otherwise need to be scrapped.

The lifter buckets, shims and lifter bores on the 3VZ-E hardly ever wear

### Now is the time....

Line-boring is possible for every shop. Peterson has the Berco BT6 available for *all* cylinder heads and blocks as big as a 440 Mopar!

Check out the standard features of the BT6 that will help you make a profit without breaking your budget.

**Peterson**  
MACHINE TOOL INC.

ASK A PETERSON USER.

5425 Antioch Drive, Shawnee Mission, KS 66202



For Further Information Call:

**1-800-255-6308**

Low Interest Financing Available

Circle 37 for Reader Service

unless another problem causes damage. A problem that could cause wear could be a bucket or that shim may have stopped rotating as they are designed to do, but this is a very rare occurrence. The lifter bore diameter should be 1.4930~1.4934~ while the bucket (lifter) should be 1.4945~1.4951~ giving an oil clearance of 0.0011~0.0021~ and a maximum oil clearance of 0.0039~.

You will also need to install the cam and check the thrust clearance. Thrust clearance should be 0.0031~0.0075~ with a maximum of 0.0098~.

Prior to final assembly, but after the valves, springs and lifters are installed, you will likely have your last opportunity to vacuum test the head again before it leaves your shop. The combustion chambers should be checked to ensure the valves are all properly sealing and the water jacket should also be checked for leaks. You should also oil the threads and heads of all bolts before installing and torquing them down.

During final assembly, coat all moving parts with oil or



*Arrow shows shim that will give you the proper clearance. It is best to try to obtain a clearance that is in the middle of the OE range to allow for future adjustments.*

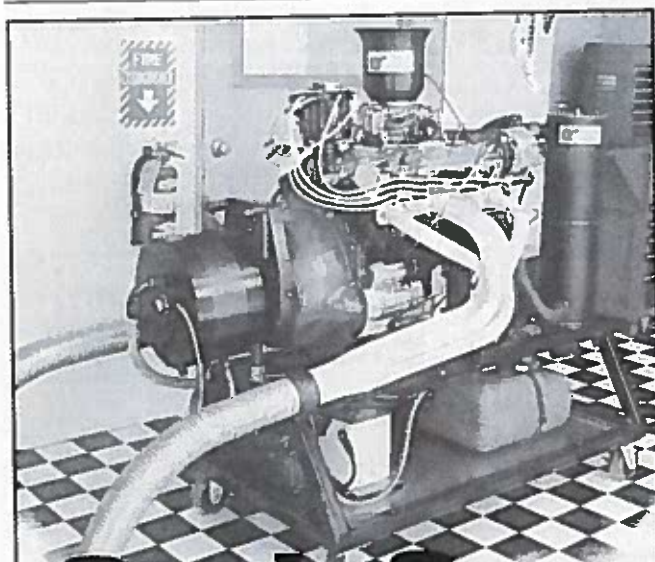
assembly fluid. Make sure the lifters move freely in their bores up and down as well as rotating. When installing the front and rear caps be sure to apply an RTV sealant to the corners. This is the last possible problem area you could have with these heads. They are well known for oil leaks and 99 percent of the time it is at the cap edges that they leak. Don't ruin a great rebuilding job by giving a customer a reason to complain of an oil leak.

Once the cam is installed and torqued down you can check the valve clearance. Intake valves should be 0.005~0.009~ and the exhaust should be 0.011~0.015~. You should always strive to set the clearance in the center of this range. It will give your customer room to work with in the event of future repairs.

Although many shops will remove the cam to change a shim, there is a much easier way. Goodson Shop Supplies sells a tool just for this procedure on Toyota heads. A specially designed pliers and wedge are used to remove and replace the shims. The pliers reach around the cam to depress the lifter, while the wedge holds the lifter down to free the shim. It is p/n VBT-40 in the Goodson catalog. Even if you only do an occasional Toyota head, the tool is well worth its low cost...under \$50.

The Toyota 3VZ-E head is nearly bulletproof. If you get one to rebuild, chances are you will have very few problems and will be able to reuse most of the parts. Although VEGE is a high volume rebuilder and does many things different from most smaller shops that may only see a few of any particular head at any one time, it proves how important consistency is. If you stay within the manufacturer's specs and check everything, you should be able to provide your customers with a quality product. **EB**

*Note: Mention of specific products or manufacturers by the author does not constitute an endorsement by Engine Builder magazine.*



# Cash Cow

**DYNomite™ Dynamometers**

**Start milking yours today... from \$9995**

call for free catalog or visit [www.land-and-sea.com](http://www.land-and-sea.com)

**LAND & SEA**

Box 96, N. Salem, NH 03073 (603) 329-5645

Circle 38 for Reader Service