K-Line®

VALVE GUIDE LINERS FOR DIESEL APPLICATIONS

By Pim van den Bergh

Guide-Liners for Diesel Applications

BY **PIM VAN DEN BERGH** PHOTOS BY **RON REGAN**

In today's diesel engines, OEMs are forced to meet stricter emissions standards — balancing between premature guide wear due to low sulfur fuels (ULSD) and the need to tighten tolerances on valve-to-guide clearances. They push the limit by reducing the amount of oil a valve stem seal is allowed to pass through in order to meet these stricter emission standards. The Guide-Liner is an excellent, economic solution to this new problem. I believe it to be of interest to take a closer look at what this system can do for you. If anything, by the end of this article, you might have picked up something new and useful or freshened up on something old and familiar because the Guide-Liner has been around for a long time.

The idea that the Guide-Liner is only for heads with integrated or cast-in valve guides (like the old Chevy 350 heads) is in the past. The Guide-Liner has evolved way beyond that and is an excellent solution in all types of cylinder heads – from multi-valve aluminum cylinder heads with guides as small as 5mm to large HD turbo-charged diesels using ultra-low sulfur diesel (ULSD).

The Guide-Liner is widely used in Europe, Latin America and Australia for engines running on abrasively dry, gaseous fuels. In the US and UK, there are engine builders who use them in top-fuel race applications with good results. The Guide-Liner, installed correctly, can and will withstand the most extreme applications.

As mentioned before, the Guide-Liner has evolved. It started out as a smooth bronze liner, followed by the Interrupted Spiral to increase oil retention.

A few years ago, K-Line Industries Inc. introduced the DFL Performance Coated Guide-Liner to offer the racing industry an improved liner that allows for tighter tolerances and less drag due to reduced friction.

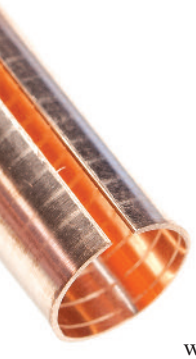
The DFL Guide-Liner uses the same foundation material (Phosphor Bronze) as the original Guide-Liner, offering the same great malleability and heat transfer, enhancing it with the qualities of DFL Coating.

The DFL Coating is capable of providing lubrication under extreme pressure (as high as 350,000 psi) making it an excellent application for situations where side-loading, extreme temperatures or very abrasive fuels are an issue, as is the case in HD turbo-charged diesel engines.

I have seen success with the DFL in these applications where low sulfur or bad quality fuels not uncommon abroad

For each guide size, there is a kit that has all the tooling required to accurately install the Guide-Liner.

Contents of a K-Line NX Deluxe Kit (listed in order as pictured, from top to bottom):
- **Reamer and bushing**
- **Brush**
- **Go No-Go Gauge**
- **Auto Installer**
- **Ball Broaches (3)**
- **Guide Top Cutter**
- **Flex-Hone®**
- **Removal Tool**



are an issue. The DFL Guide-Liner is installed the same way as the normal Guide-Liner, however, there is one big difference — this liner should not be honed. The DFL will damage or clog your hone and the hone will remove or damage the DFL coating. The nice bonus of the DFL Guide-Liner is that a ball broach gets a lot longer life sizing these versus a traditional Guide-Liner.

The Process

Short of reaming the guide and using oversized valves, when done correctly, the Guide-Liner process is the fastest and most accurate way to reclaim the guide in a cylinder head. The process does require special tooling (see photo above).

A set of seat bushings, air drill, air hammer and a broach driver are the basic tools and are a one time purchase. Then for each guide size, there is a kit that has all the tooling required to accurately install the Guide-Liner.

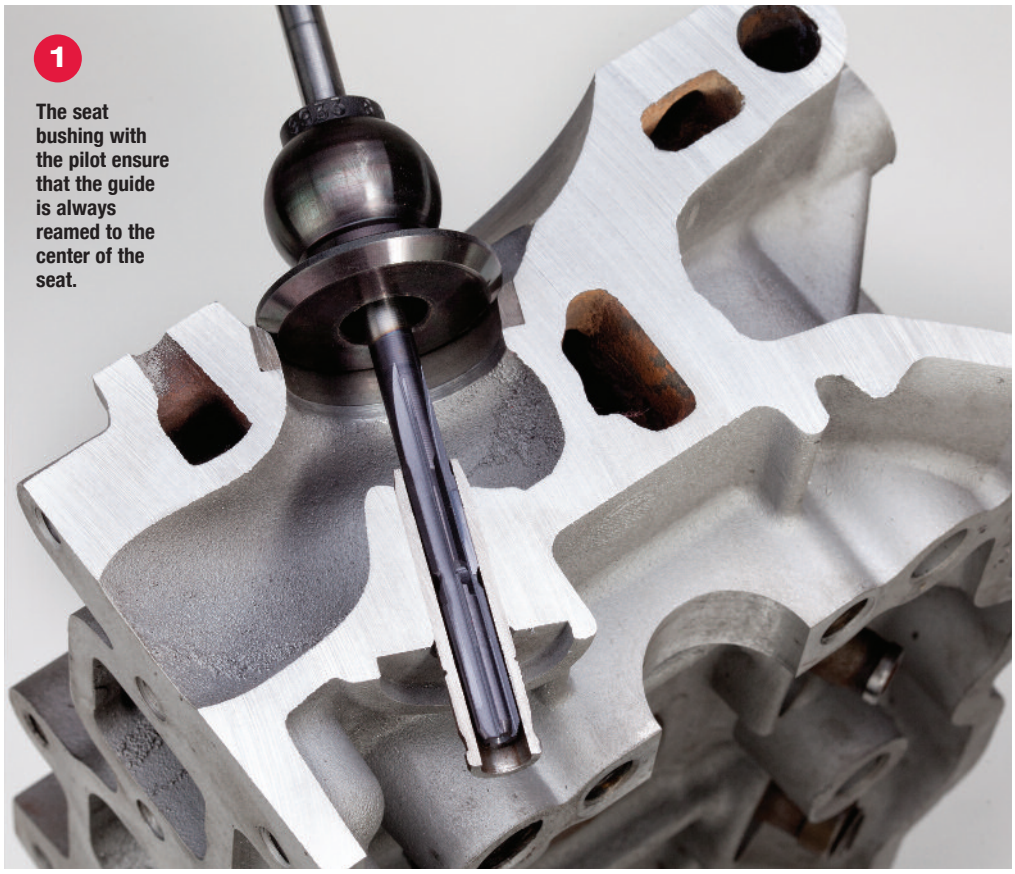
A set of seat bushings, air drill, air hammer and a broach driver are the basic tools required for the process.

GUIDE-LINERS FOR DIESEL APPLICATIONS

BY **PIM VAN DEN BERGH**

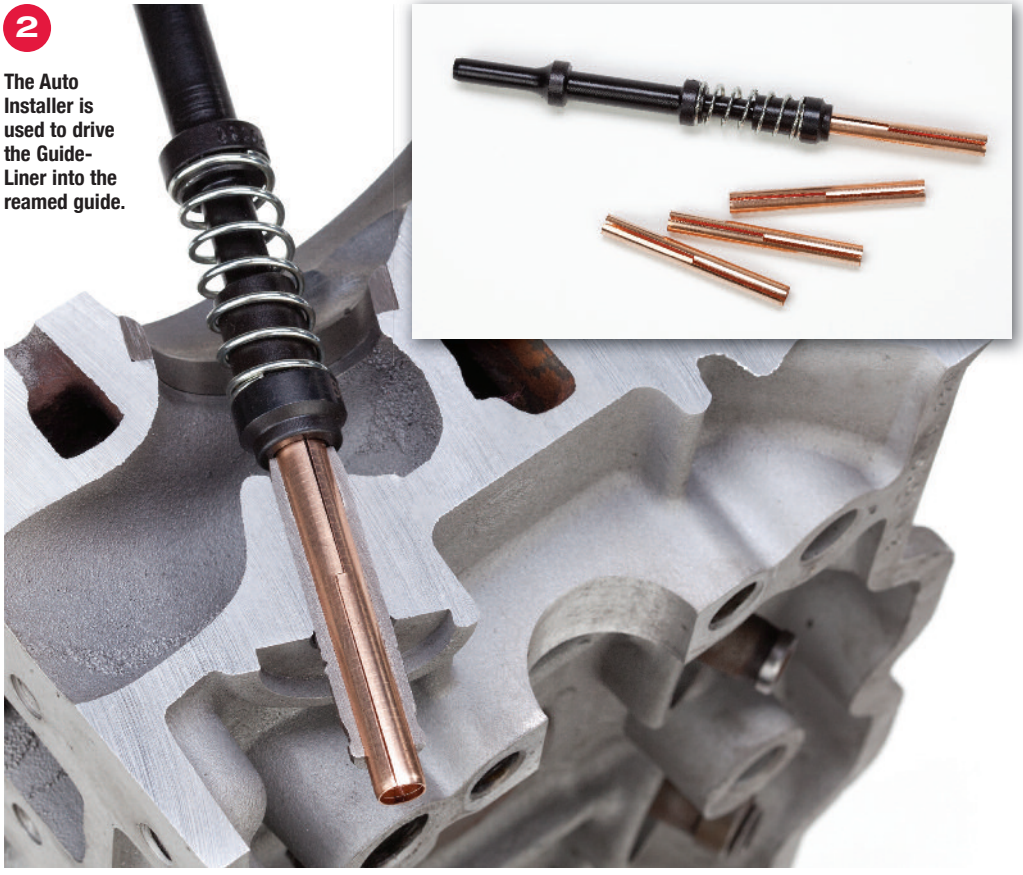
4 Simple Steps To Install a Guide-Liner Correctly

1 Through the combination of the reamer pilot, the reamer bushing and the seat bushing, perfect alignment is maintained between the center of the guide and the center of the seat during the reaming process. This is the foundation of the Guide-Liner. That perfect center of the guide to the center of the seat drastically reduces the amount you need to machine the seat to a minimum. Lets face it, cutting a valve seat on any machine available in today's market depends on the condition/position of the guide to the seat. The better you keep the two in line, the less work you have cutting the seat.



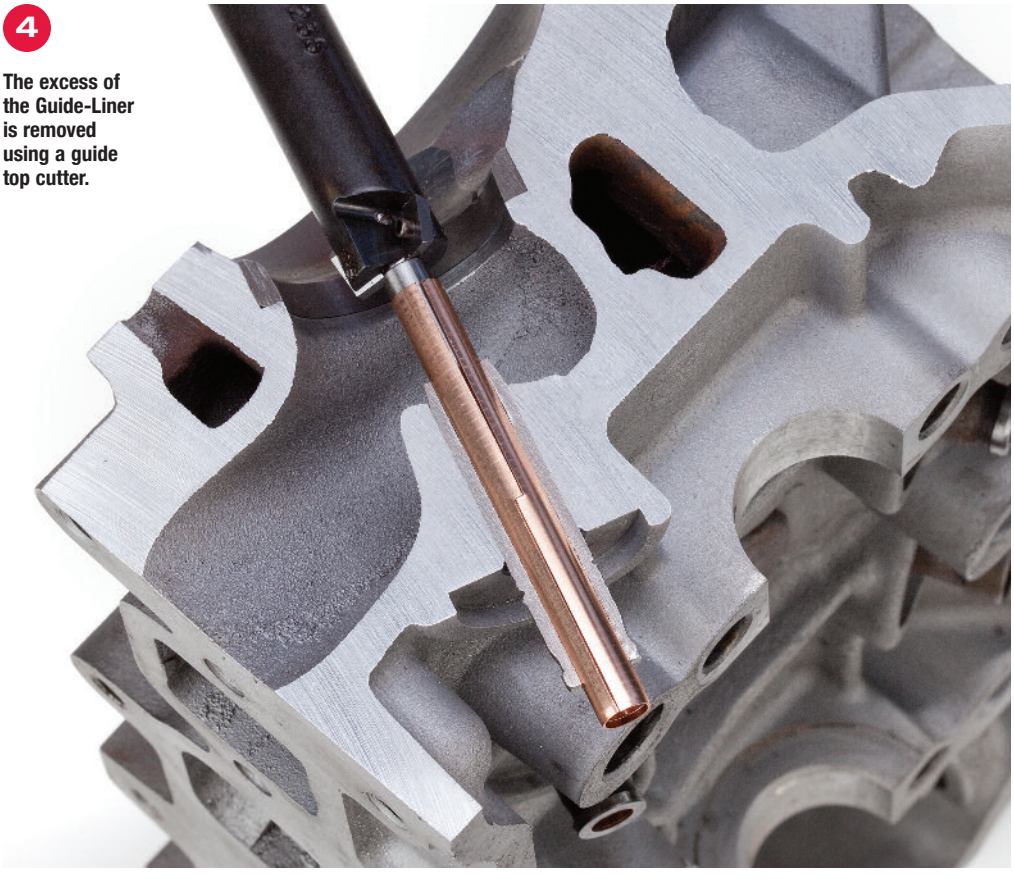
1 The seat bushing with the pilot ensure that the guide is always reamed to the center of the seat.

2 After reaming the guide, the Guide-Liner is installed. The Guide-Liner is a split, phosphor bronze, thin wall bushing that can be installed in the guide from the seat or the spring side. Using the Auto Installer (provided in the kit) and a short stroke air hammer, the Guide-Liner slides effortlessly into the reamed guide. Preference is to install the Guide-Liner in a clean, dry guide; no oil required. No need for the use of any type of adhesive – as a matter of fact, I strongly advise against it.



2 The Auto Installer is used to drive the Guide-Liner into the reamed guide.

3 The Ball Broach process serves two purposes – one is to "lock" the Guide-Liner in place inside the existing guide, the other is to size the Guide-Liner to its required size.



4 The excess of the Guide-Liner is removed using a guide top cutter.

3 Sizing of the liner can be done using a ball broach, carbide sphere or roller burnisher. With a light oil or special lube (like the K-Line Bronze Lube KL1224 and a guide brush, provided in the kit) pre-lube the ID of the Guide-Liner. This allows the Guide-Liner material to size or "flow" better during the broaching process. This step serves two purposes – one is to "lock" the Guide-Liner in place inside the existing guide, the other is to size the Guide-Liner to its required size.

4 After the desired size is obtained, the excess of the Guide-Liner is removed using a guide top cutter provided in the kit. This step removes any excess Guide-Liner material and squares off the guide. Always do this on both sides of the guide and always after the broaching or sizing operation. It is very important that no Guide-Liner material is left protruding out of the guide; on the spring side, this can prevent oil from entering the guide. As for the valve head side, it can cause the Guide-Liner material to overheat and burn, especially in the exhaust guide.

These four easy steps – Ream, Install, Broach and Cut – with all the tools in place, takes an experienced operator less than a minute per guide, on average.

NOTE: In the pictures, a lightweight aluminum head is used for demonstration purposes. In reality, working on a big diesel head, the steps are the same with one big difference — you don't easily flip a 100-lb. head over to trim the Guide-Liner. The system works from the seat side and can be completed without having to turn the head over. Most shops trim the spring side as the very last step, before it goes onto the seat and guide machine.

GUIDE-LINERS FOR DIESEL APPLICATIONS

BY **PIM VAN DEN BERGH**

For the reaming operation, there are jigs or stands available to align and assure the seat bushing is pressed in the seat during the reaming of the guide. These tools are a great benefit, however, not practical when doing big diesel heads. A lot of machine shops prefer holding the seat bushing by hand or using a drill-mounted fixture due to speed, flexibility and ease of use. In all cases, the long pilot on the reamer and the seat bushing have no problem making sure the reamer stays on center, especially having the weight of the head keeping the work piece steady.

The tooling kit contains a few more tools that I did not mention in the previous steps.

The Go No-Go Gauge: This tool is used to check how your reamer is performing in regards to size and whether the reamed hole is straight. It is important to sporadically check the reamed guide from both sides, spring side and seat side to verify how your reamer is performing.

The Flex-Hone®: This used to be the fifth step of the process, however, when using the DFL Guide-Liner, honing is not an option. When using the traditional Guide-Liner you can hone, but it's not required. I have a love-hate relationship with this tool. It is great for finishing off the guide, removing burrs the top cutter might have left behind and leaves a nice crosshatch finish (in addition to the Interrupted Spiral). The problem after honing is cleaning out the honed guide. The honing process, especially being an abrasive operation, always leaves debris behind. It is extremely important to thoroughly clean the guide. The Interrupted Spiral is great for oil retention, however, it also can store hone residue that can severely damage the valve stem if not cleaned out properly. Hot water, soap and a brush is the best way to clean the guides. Solvent-based cleaners tend to enclose dirt or debris rather than remove it.

The Removal Tool: When one follows the above-mentioned steps religiously, the Guide-Liner will not move, come loose or fall out. As a matter of fact, I challenge anyone to remove the Guide-Liner – and not damage the reamed hole – without the Removal Tool that is included with the kit. The Removal Tool will remove a guide that has been in use for many years without damaging the original reamed guide and will allow you to reinstall a new Guide-Liner.

Reasons why guides fail in diesel applications:

1. Oil supply, or lack of, mainly regulated by the valve stem seal.
2. Type of load the engine functions under. A constant load cycle or duty cycle (marine, industrial) tends to push oil out of the guide. Much more than a constantly changing load and variable or changing speeds seem to allow fresh oil to enter the guide.
3. Excessive turbo boost can starve an intake valve guide.
4. Stem to guide clearance – Too much and it will cock the valve and wear. Too little and it will scuff the valve stem.
5. Inadequate oil retention of the guide ID – Often HD guides are spiraled for better oil retention.
6. Side loading of the valve stem due to rocker arm actuation or incorrect machining of the seat – too much seat run out.
7. Excessive temperatures in the guide, especially when it protrudes into the

The Go No-Go Gauge is used to check how your reamer is performing in regards to size and whether the reamed hole is straight.

The Flex-Hone® was once the fifth step of the Guide-Liner process, however, when using the DFL Guide-Liner, honing is not an option. When using the traditional Guide-Liner you can hone, but it's not required. (Flex-Hone® is a registered trademark of Brush Research Manufacturing Co. Inc.)

The Removal Tool will remove a guide that has been in use for many years without damaging the original reamed guide and will allow you to reinstall a new Guide-Liner.

port or the valve seat heat transfer is limited due to incorrect seat width, or improperly installed seat insert.

8 Cylinder pressure – The higher the combustion pressure, the higher the risk of the valve being pushed around, causing side-loading or misalignment.

9 Heat dissipation –Most of the dissipation is done by the seat; if it is not doing its job, the strain is on the guide. The guide needs the ability to give off its heat to the head.

10 Incorrect machined guide, taper or out of round.

11 Uneven seat wear causing cocking of the valve.

12 Excessive heat in the valve, causing oil corrosion and metal-to-metal contact.

13 Excessive valve rotation.

14 Abrasive wear due to poor air filtration, especially on the intake side.

15 Corrosive wear, especially in the exhaust valve, due to fuel impurities and additives (or lack of). With today's low sulfur diesel, proper guide material is more important than ever. Going to extremes, there may be chemical formations at high temperatures that cause breakdown of the oil film or, on the other end of the spectrum, low temperature condensation of acidic gases that form at idle and break down the oil film.

16 When replacing a guide, two common failures can occur with improper head to guide clearance. First, if it's too loose, it can move or cause over-heating because it can't dissipate the heat properly. In some cases, if the guide bore was damaged during extraction, an oil leak can form around the OD of the guide and the head. Second, if it's too tight, the guide ID will distort and require reaming. Another reason for failure is material choice. Replacing a guide is not just replacing a cast iron tube (unless you install a Guide-Liner); not all guide materials are made the same.

Guide-Liner Advantages

If we look closely at the reasons for guide failure, lubrication, heat and load are the three main factors. This is where the Guide-Liner excels.

The chosen material for both the DFL Liner and the traditional Guide-Liner is Phosphor Bronze. It's an alloy of copper with 3.5 to 10% of tin and a significant phosphorus content of up to 1%. This alloy is notable for its toughness, strength, low coefficient of friction, and fine grain allowing cold workability. This combination of ingredients provides good thermal conductivity required to dissipate heat.

1) Lubrication – In addition to the interrupted spiral, the phosphor gives the Guide-Liner lubricating qualities that act as oil reservoirs providing constant lubrication to the valve stem. On the DFL version, the coating is capable of working with a lot less oil.

2) Heat – Good heat dissipation is key. Phosphor Bronze adapts very well to the reamed hole and this is why it's best to be installed in a dry, clean, reamed guide to maximize contact, thus heat transfer. This is also why using any type of adhesive is not advisable; most adhesives don't dissipate heat very well and act as insulators.

3) Mechanical – The Guide-Liner process might use a malleable material during the installation process however the finished product is case-hardened during the sizing of the Guide-Liner by the ball broach. This gives the Guide-Liner good resistance to mechanical wear. But that is not all – on the DFL and the traditional Guide-Liner, the Phosphor Bronze has such a low coefficient of friction and high wear resistance, causing it to act as small slide bearings that contact the valve stem, but do not abrade it.

So, why use the Guide-Liner process? Why not just replace the guide and be done with it? Well, removing the original guide is not always the easiest process and can damage the guide bore in the head, especially in smaller aluminum diesel heads. Pressing in the new replacement guide will require reaming of the replaced guide because you will distort the guide, especially if you have too much of an interference fit with the head.

Finding the right part – When working on newer late model heads, some parts might not be available. There are cases where the OEM recommends replacing the head and no parts are available. If you have the Guide-Liner process in place, you can basically tackle any head that comes into your shop. The process does not discriminate to size. For example, if you have a 7mm kit, you can do any head with 7mm guides. No need to stock guides for each type of head. Seat to guide concentricity = less machining. On performance heads where the guides are part of the porting job, replacing a guide can be time consuming. The Guide-Liner only repairs the ID, avoiding the need to re-work the port.

Speed – The time it takes to press out the old guide, press in the new one, ream it to size and re-work the seat is considerably longer than the Guide-Liner process. Just the time alone saved machining the seat on center pays off using the Guide-Liner process.

Flexibility – The Guide-Liner allows you to fine tune the size using the broaching process weather you use the carbide balls or the ball broaches the guide can be manipulated to the size you want and if you make a mistake you can simply remove the Guide Liner and start over. Same if a head comes back after many years of use remove the old Guide-Liner and press in a new one.

Cost – As I explained earlier, each guide size requires its own installation kit and a new user starting from scratch will run into the fact that costs add up. I have found that most successful users build up their tooling coverage over time, starting with the more popular sizes. That is the beauty of the system – you are not required to buy all sizes at once. So, you can start out with one or two sizes and see the profits recover your investment.

Troubleshooting

As you are using the Guide-Liner process, you will run into situations that raise questions. For starters, the Guide-Liner process is a great repair system, but it is not Superman. There are situations where the liner won't work. For example, if a timing belt breaks or there is another type of catastrophic failure, chances are the valves hit the pistons and they are bent to such extent that they cracked the guides, making them unsuitable for any type of repair. Other examples are:

• Some powdered metal guides are a lot harder and more brittle, which will require you to be more careful in the sizing process. Where a cast iron guide will flex, some powder metal guides won't and will often require the use of a thinner wall liner that requires less expanding. All these different wall thicknesses are available. I have also found that some guides on smaller car diesel engines can crack on the thinner stem seal side. A thinner liner (requires less expanding) often solves this problem. However, I often leave the seal in place until I use the guide top cutter. The press fit of a positive seal is often enough to prevent the guide from cracking in the seal area.

GUIDE-LINERS FOR DIESEL APPLICATIONS

BY PIM VAN DEN BERGH

• Some guides may be too long and there is no standard liner available. I have solved this problem by installing two liners in the guide. Insert one from the seat side and one from the spring side and have them meet somewhere in the middle. In cases where the overall length of liner is short 4 to 6mm or less, I will insert the Guide-Liner from the spring side. The broaching will stretch the liner out and whatever I am short (remains recessed inside the guide), stays that way. The fact that the liner is somewhat recessed into the guide actually helps it, especially on the exhaust side, by protecting the Guide-Liner from direct exposure to high temperatures.

• Tooling wear. Just like with any tooling out there, there will be times the reamers will eventually wear. However, given the proper care, they last a very long time. The nice thing is that Go-No-Go gauges are available to verify the reamers function to size. The ball broaches are most prone to wear and require upkeep using a light lube. Their life can be extended considerably with proper maintenance. The alternative to ball broaches is the use of carbide sizing balls. These are not cheap, but will not wear. There is also the risk of losing them and replacement costs can be expensive. I have seen attempts to weld the carbide balls on a metal extension, trying to combine the ball and the broach concept into one – combining the benefits of both. And finally, the best but most expensive way is the roller burnisher. Its cost and speed make it the least popular.

The last thing I want to mention is the chrome ball broach. The fact that it wears makes it a tool that requires control of its condition. Once the industrial chrome layer is worn, it will stop working. At that point, it will either push the Guide-Liner out of the bore instead of sliding through because its surface is too rough – or, it will score the ID to such an extent that the Guide-Liner material turns into a coarse surface that can cause premature stem wear. Whenever I run into a situation where a customer has a problem or premature failure, in most cases I can trail it back to tooling not being maintained or not working correctly.

I have been calling on machine shops around the world for more than 10 years. I have also used the Guide-Liner process at the PER level for many years prior to that. Everyone I talk to, who is successful using the Guide-Liner process, says the same thing – "It's great, it works, but you have to follow the steps." As long as you follow the steps and maintain your tools, the system works, saves you time and makes you money.

Pim van den Bergh is the International Sales Manager for SBI, the premier worldwide supplier of cylinder head components to the aftermarket. SBI is the worldwide distributor of the K-Line Guide-Liner system. You may contact him at 616-990-1843 or email pim@sbintl.com.