

Comprehensive Guide to Cylinder Head Spacer Shims: Engineering Principles and Precision Installation

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In the realm of precision engine rebuilding and performance machining, maintaining the structural and geometric integrity of the internal combustion engine is paramount. One of the most critical yet frequently misunderstood components in the engine builder's arsenal is the **cylinder head spacer shim**, often colloquially referred to as a "head saver shim." These components are engineered to solve a specific set of problems that arise during the resurfacing of cylinder heads and engine blocks. When a technician machines a head to correct warpage or improve surface finish, they effectively alter the factory-specified dimensions of the engine. This change can have cascading effects on compression ratios, valve-to-piston clearances, and valvetrain geometry.

The Fundamental Role of Cylinder Head Spacer Shims

Cylinder head spacer shims are thin, precision-manufactured plates—typically made of high-quality copper or stainless steel—designed to be installed between the engine block and the cylinder head gasket. Their primary function is to restore the "assembled height" or the distance between the crankshaft centerline and the top of the cylinder head. While modern machining techniques allow for incredibly flat surfaces, the removal of material is inevitable. A standard 0.020-inch shim is the industry benchmark for compensating for moderate to heavy resurfacing.

Why Material Removal Requires Compensation

Engine designers calculate combustion chamber volume, piston-to-deck height, and cam timing based on specific measurements. When as little as 0.010 to 0.015 inches is removed from the head or block surface, several critical variables are compromised:

- Compression Ratio Inflation:** Reducing the volume of the combustion chamber increases the static compression ratio. In forced induction or high-compression naturally aspirated engines, this can lead to catastrophic detonation or pre-ignition.
- Valvetrain Misalignment:** In Overhead Valve (OHV) engines, lowering the head moves the rocker arms closer to the lifters, necessitating shorter pushrods. In Overhead Cam (OHC) engines, it moves the camshafts closer to the crankshaft, which can introduce slack into the timing chain or belt, effectively retarding the cam timing.
- Interference Risks:** In "interference" engine designs, the margin of error between the valve at full lift and the piston at Top Dead Center (TDC) is razor-thin. Machining without shimming can lead to mechanical contact and engine failure.

Technical Specifications and Material Science

The selection of a spacer shim involves more than just picking a thickness. The metallurgy of the shim must be compatible with both the block and the head material to prevent galvanic corrosion and ensure a permanent seal. Most professional-grade shims, such as those produced by **Enginetech** or **Fel-Pro**, utilize dead-soft copper or specialized steel alloys.

Comparison of Shim Materials and Applications

The following table outlines the common materials used in the manufacture of cylinder head spacer shims and their

respective mechanical properties.

Material Type	Typical Thickness	Thermal Conductivity	Sealing Requirement	Best Use Case
Dead-Soft Copper	0.020"	High	High-Tack Sealer Required	Iron Blocks / Aluminum Heads
Stainless Steel	0.010" - 0.020"	Moderate	Multi-Layer Integrated	High-Performance Racing
Composite/Shim Combo	Variable	Low	Pre-Coated	General Passenger Vehicles

Copper remains the preferred choice for many 0.020-inch shims because of its ability to “conform” to minor surface irregularities. When used in conjunction with a high-quality sealant, a copper shim acts as a secondary gasket that maintains the thermal path between the head and the block.

The Mathematical Impact on Combustion Chamber Volume

To understand the necessity of a 0.020-inch shim, one must apply the geometric formula for cylinder volume. The volume of the material removed can be calculated as the volume of a cylinder with a height equal to the machining depth.

Formula: $V = \pi \times r^2 \times h$

Where:

- V: Volume of material removed.
- r: Radius of the cylinder bore.
- h: Thickness of the material removed (e.g., 0.020").

For a typical 4-inch bore engine, removing 0.020 inches of material results in a volume loss of approximately 4.1 cubic centimeters (cc) per cylinder. In a small-displacement engine, this change can swing the compression ratio by half a point or more (e.g., from 9.5:1 to 10.1:1). Utilizing a **0.020 cylinder head spacer shim** effectively restores that 4.1cc of volume, returning the engine to its OEM specifications.

Procedural Guide for Professional Installation

Proper installation of a spacer shim is critical. Failure to follow the correct sequence can result in coolant leaks or combustion gas bypass. These shims are generally installed on the **block side** of the assembly, not the head side.

Step-by-Step Execution

1. Surface Preparation: Both the cylinder head and the engine block deck must be surgically clean. Use a non-residue brake cleaner or acetone. Any oil or old gasket material will prevent the shim from seating.
2. Inspection for Burrs: Check the edges of the shim for any manufacturing burrs. Even a microscopic protrusion can lead to a localized pressure point and eventual gasket failure.
3. Sealer Application: Most 0.020" shims require a sealer between the shim and the engine block. A micro-thin layer of high-tack spray adhesive or specialized copper coat is recommended. This prevents “creeping” and ensures a fluid-tight seal against the block.
4. Orientation: Align the shim with the dowel pins on the block. Ensure all coolant passages and oil galleries are perfectly unobstructed.

5. Gasket Placement: Place the primary head gasket (e.g., a standard Fel-Pro or DNJ gasket) on top of the shim. The shim effectively becomes an extension of the block deck.

6. Torque Sequence: Follow the manufacturer's torque-to-yield (TTY) or standard torque specifications. It is often recommended to perform the torque sequence in three incremental stages to allow the shim and gasket to "set" evenly.

Case Study Analysis: Chrysler and Toyota Applications

The provided data highlights several specific engine families that frequently utilize 0.020-inch spacer shims. These engines are known for having limited tolerances regarding deck height.

1. The Chrysler/Dodge 2.0L DOHC (Neon/Avenger)

The 95-99 Chrysler 2.0L "Y" code engine is a prime candidate for shimming. This engine utilizes a DOHC configuration where cam timing is sensitive to the distance between the crank and the head. If the head is milled without a **Cylinder Head Spacer Shim for 95-99 Avenger/Neon**, the timing belt tensioner may reach the end of its travel, or the cam timing may retard by several degrees, leading to a loss of low-end torque and poor idle quality.

2. Mopar Big Block (BBM) and Small Block (SBM)

In classic Mopar builds (SBM 318/360 or BBM 383/440), head shims are often used to maintain the correct geometry for the intake manifold. When the heads are milled on a V-style engine, the heads move closer together, which can prevent the intake manifold bolt holes from aligning. A 0.020 shim helps maintain the intake manifold "fitment" without requiring additional machining of the intake faces.

3. Toyota 2.4L (22R/22RE Series)

The Toyota 2.4L is a workhorse engine, but its aluminum head is prone to warping if overheated. Frequent resurfacing is common. The **FEL-8807SP** shim is a staple for these engines to ensure the timing chain tensioner operates within its designed window and to prevent the valves from kissing the pistons during high-RPM operation.

Troubleshooting Common Failure Modes

Even with high-quality components like **DNJ HS217** or **Enginetech** products, failures can occur if the ecosystem of the engine is not considered.

Leakage Between Shim and Block

This is the most common failure. It usually occurs because a sealer was not used or the surface finish of the block was too rough. Shims require a relatively smooth surface (typically 50-60 RA or better) to seal effectively. If the block deck is pitted, the shim may not be able to bridge the gaps.

Overheating and Thermal Expansion

Because the shim introduces an additional layer of material, it also introduces a new thermal interface. If the shim material has a significantly different coefficient of thermal expansion than the block or head, it can lead to "scrubbing" of the gasket. This is why copper is preferred in many cast-iron block/aluminum head combinations; its high ductility allows it to absorb the movement caused by thermal cycles.

Evaluating Performance: The Pros and Cons of Shimming

When deciding whether to use a spacer shim, technicians must weigh the benefits of restoring geometry against

the complexity of adding another potential leak path.

Feature	Advantage of Shimming	Potential Limitation
Compression Ratio	Restores OEM compression, preventing detonation.	Adds an extra sealing surface.
Valvetrain Geometry	Maintains correct pushrod length/cam timing.	Slightly increases the height of the engine.
Cost Efficiency	Saves expensive heads from being scrapped.	Requires meticulous cleaning and sealing.
Timing Alignment	Keeps timing belts/chains at proper tension.	N/A

Advanced Engineering Considerations: OHC vs. OHV

The impact of a 0.020-inch reduction in head height differs drastically between engine architectures. In an **Overhead Valve (OHV)** engine, the primary concern is pushrod preload. If the head is lower, the pushrod is effectively “longer,” which can bottom out hydraulic lifters or cause valves to stay partially open. A shim eliminates the need for custom-length pushrods.

In an **Overhead Cam (OHC)** engine, the concern shifts to the timing drive. As the distance between the crank and cam gears decreases, the “slack” side of the belt or chain grows. While the tensioner can take up some slack, the geometry of the belt path changes. This results in the camshafts being “behind” the crankshaft in their rotation (retarded timing). For every 0.010 inches removed, cam timing can retard by approximately 1 degree. A 0.020 shim corrects a 2-degree timing error, which is significant enough to be felt in the engine’s power band.

Maintenance and Long-Term Reliability

Engines rebuilt with **Enginetech Cylinder Head Spacer Shims** or similar high-quality spacers have shown long-term reliability comparable to OEM assemblies, provided the installation parameters are met. It is a misconception that shims are a “temporary fix.” When properly seated with the correct sealant, the shim becomes a permanent part of the block’s deck structure. The key is to treat the shim-to-block interface as a static joint and the gasket-to-head interface as the dynamic sealing surface.

Technical professionals should always verify the shim thickness with a micrometer before installation. While 0.020 inches is the standard, variations in manufacturing can occur. Furthermore, if a block has been “decked” (machined) and the head has also been machined, a single 0.020 shim may not be sufficient. In extreme cases, specialized builders may stack shims or use custom-thickness Multi-Layer Steel (MLS) gaskets, though the latter is often preferred for high-boost applications.

Conclusion and Industry Implications

The use of cylinder head spacer shims represents a sophisticated intersection of salvage operations and precision engineering. By allowing technicians to reuse cylinder heads that would otherwise be discarded due to excessive material removal, these shims provide an environmentally and economically sustainable solution for engine remanufacturing. However, the success of their application depends entirely on an understanding of the underlying physics—specifically compression ratios and valvetrain geometry.

As engine designs continue to move toward higher compression and tighter tolerances, the role of the "head saver" shim remains vital. Whether it is a **Mopar Big Block** or a modern **Chrysler 2.0L**, the 0.020-inch spacer serves as a critical buffer, ensuring that the complex dance of pistons and valves remains perfectly choreographed. For the senior technical writer and the automotive engineer alike, the shim is a testament to the fact that in mechanical systems, even twenty-thousandths of an inch can be the difference between peak performance and catastrophic failure.

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