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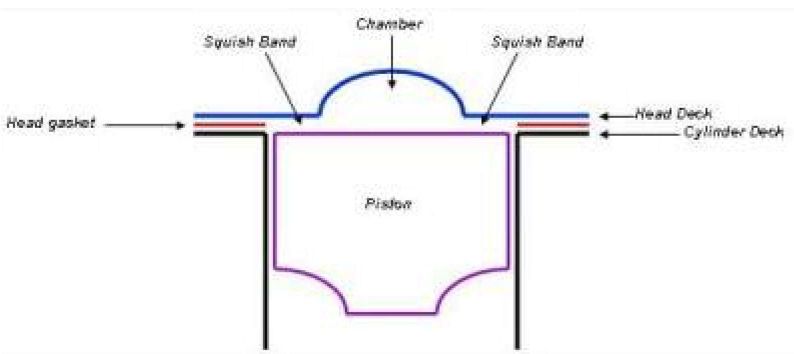
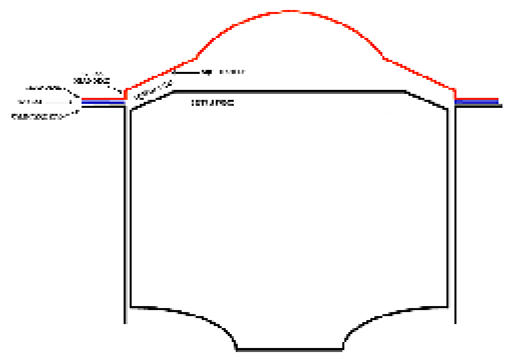
Squish Band

The squish (AKA "quench") band refers to the area or areas,
where the piston comes very close to the cylinder head while passing through top dead center (TDC). [1]



[2]


[3]

Even though the fire has already been lit, these areas still contain unburned air/fuel mix as the piston arrives.
The piston sandwiches the air/fuel up next to the head, causing it to "squish", and shoot out toward the flame front.
The result is more chamber turbulence, better atomization of the fuel, and the squish band even has a cooling effect on the fuel.
They result in more complete combustion (more power and better fuel mileage) as well as better resistance to detonation.
The squish band clearance would normally probably be in the .040" to .060" range from the factory.
But when you put it together yourself, you can take some extra time and effort and optimize certain things.
Ideally you'd like it more on the order of .030" (or .035" if you're using a full cast iron cylinder).

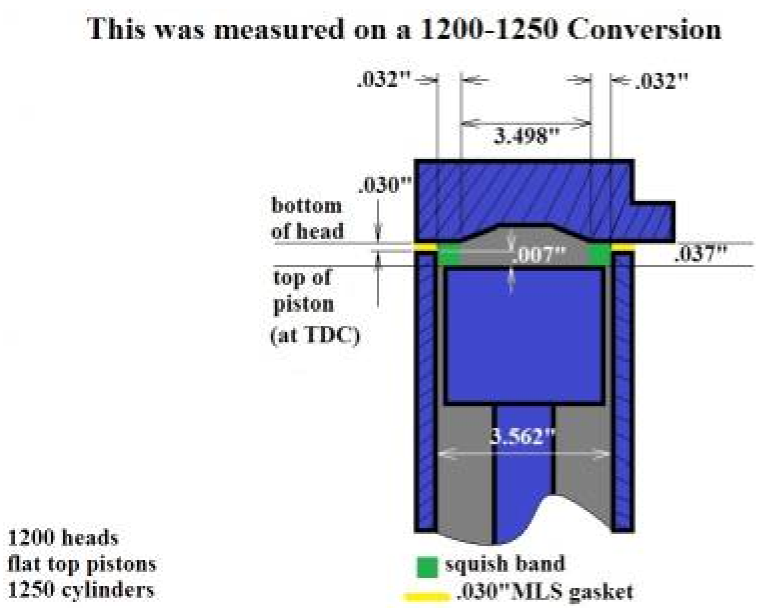
You can optimize the squish band by adjusting the height of the cylinder head relative to the piston.
(such that the piston come closer to the head)
This will give you a little free power, better mileage, and more resistance to detonation.
If you let it get too close, you can actually get contact due to things like thermal expansion and piston rock.

When 883 heads are used over the larger 3-1/2" 1200 bore or 3-9/16" bore 1250 cylinders, a squish band is gained around the perimeter of the chamber.

Measuring the Squish Band

Indirect Method

You can use a piston height gauge to measure how far above or below the cylinder deck the piston is sitting at TDC.
Then add that measurement to the gasket thickness.
This method works fine with both decks being flat.
But it doesn't work well with heads that have angled domes.

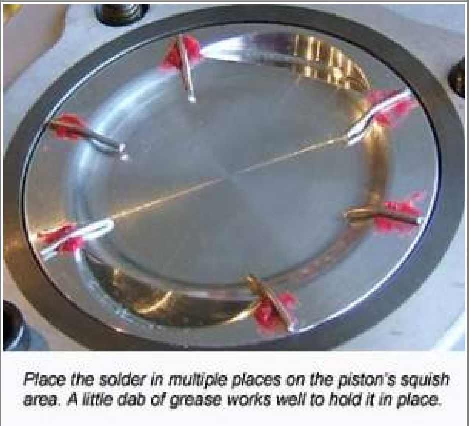


[4)]

Direct Method

You'll be placing some soft material, such as .065“ solder, onto the squish band area of the piston.
(clay has been used for this also but it's not as accurate as using solder which won't change thickness)
Rotate the engine through TDC, remove the material, and measure it's thickness.
It takes more time than measuring the deck as in above because it requires an extra disassembly/reassembly cycle of the cylinder head.
But this method works great with flat or angled head surfaces. The tools required are no more than if you are installing the heads.

- Place the solder in multiple places around the piston top.
  Grease works best to hold the solder but if using tape, keep it below the squish band.
- Install the head gaskets and heads then follow the torque procedure to full torque spec.
  Next, remove the heads following the removal sequence in the FSM to keep from warping them.
- Then measure the compressed side of the solder pieces with a caliper.
- Write the measurements down to conclude and average the squish band dimension.

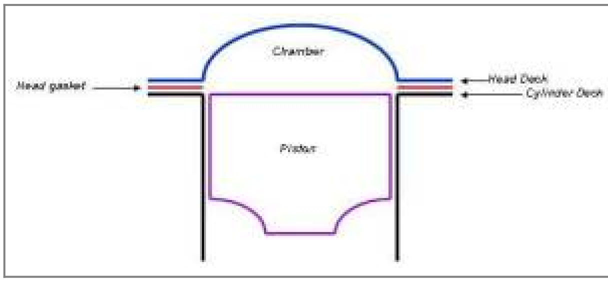
Solder held with grease. [5]	Remove the heads to reveal how far the solder was compressed. [6]	
		
Measure the compressed side of the solder pieces. [7]	Write the measurements down to conclude and average squish band dim. [8]	
		

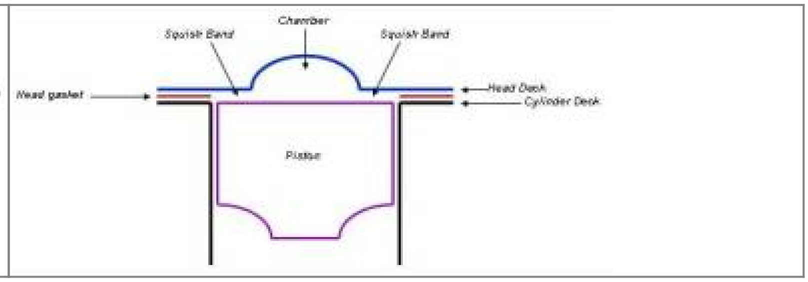
Gaining a Squish Band Due to a Conversion

Converting an 883:
An 883 head has a hemi chamber with no squish band but it's chamber is only 3” in diameter to match the 3“ bore size of the 883. [9]
What's fundamentally wrong with the hemi design is that it gives very poor chamber turbulence.
Poor chamber turbulence means poor air/fuel mixing, resulting in pockets of fuel.
It makes the chamber detonation prone. For this reason, all the hemi-chamber XL motors are & were limited to 9:1 compression.
(all 883's, and 88-03 1200's that is except 1200S models which had Buell lightning heads and 10:1 compression)

However, when you do a conversion, a very good side effect is that you gain a squish band around the perimeter of the chamber.
This is because you're now putting a 3-1/2” (1200) or 3-9/16“ (1250) diameter piston under that hemi chamber.

883 head on 883 cylinder (no squish). [10]	883 head on 1200 or higher cylinder (squish gained) Also 1200 head on 1250 or higher cylinder w flat top pistons [11]





Now with the squish band and as the piston passes through TDC,
Air & fuel that's trapped between the head and the piston in the “squish band” gets squeezed out.
(like stepping on a tube of toothpaste).
The result is more chamber turbulence resulting in better mixing, better efficiency, and less detonation.
In fact most people move to 10:1 compression when doing a conversion because the better chamber turbulence makes it possible.

Converting a 1200:

Machined Squish Band

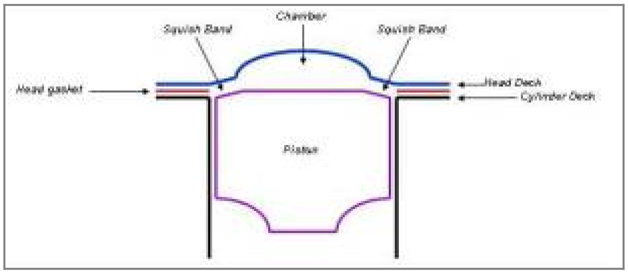
Deciding ahead of time on the performance upgrades you want is important.
When you prepare heads, the chamber wants to get bigger.
This happens for a variety of reasons.
The valves are sunk in the heads to gain (valve to valve) and (valve to piston) clearance.
As well as correct valvetrain geometry, and they're heavily unshrouded to improve low lift flow.
As in the head picture above, all these things increase chamber volume and makes the compression ratio lower.

At the same time, moving up the power scale really calls for more compression, not less, as the cams you'll use bleed off more compression.
You can deck the heads to drop the chamber volume somewhat, but that has limitations and bad side effects.
However, the coarse adjustment for the CR needs to be the piston and head decking should only be used for fine adjustments.

Therefore, if you do your conversion with the standard dished conversion pistons, you put some constraints on future performance work.
You're simply not going to be able to run as much cam or do as much head work so long as those standard conversion pistons are in your motor.

Check with your engine builder / supplier for further assistance if you're looking for a complete performance package.

Piston and head with matched squish band. [12]



Reverse Dome

A piston with a reverse dome has a dish in the middle of it.
That dish is needed because when doing a conversion, you've got a chamber that's sized for an 883 and a piston that's sized for a 1200 or 1250.
That has the effect of greatly increasing compression ratio.
In order to make this combination work at 10:1, the piston needs a dish in the top of it as shown below.
Also notice how the piston has a shelf around it's perimeter that's about a quarter inch wide.
That's to meet the underside of the head and create the squish band.
The reverse dome conversion pistons below are a “bolt-in”, meaning they require no head work, they're made to work with stock 883 heads.

The squish surface area, as a percentage of the total area of the chamber, runs about 25%.
You'd like more on the order of 35% for optimum chamber turbulence.
You can buy 30° reverse dome pistons and get the heads machined to match the piston angle.
Notice the head below has an angled dome all the way around it's perimeter.
This angle is fairly steep at 30° to match the 30° angled piston squish surface.

By making the dome real tall, you can end up with more squish band surface area than the standard dished conversion piston.
Tall domes are normally associated with high compression ratios, but the dish the middle of the piston is to get the CR back down to something streetable.
And removing material around the perimeter of the chamber reduces the shelf the air has to go around as it enters and exits the cylinder, improving breathing.
30° degree domes have been used in race bikes for forever.
But because the tall domes brought high compression ratios, this design was largely confined to race applications.
By dishing the middle of the piston deeply as shown below, the CR can be used on street bikes.

Reverse dome piston. [13]	30° Reverse dome piston. [14]	Heads machined to match the pistons. [15]

Lightning Heads

1200S heads and the older (pre-rubber mount) SE heads, 96-98 Buell S1 heads, 97 Buell S3 heads, 97-98 Buell M2 heads and Buell Blast heads are the same. [16]
These are what we call “Lightning” heads.
62cc chamber with a 10° cast in squish shelf, 1.715/1.480 valve sizes, the old low floor, squared off bowl ports like all the hemi heads etc.
All 1200S motors came with flat tops just like every other Evolution Sportster.

The Lightning head was the first generation performance head from HD for the XL motor.
All they did was take the Hemi head and add a bunch of material to the chamber to bring it down from 67cc to 62cc.
And they dual plugged some of them (1200S and the later SE versions). Ports and valve sizes stayed the same as the hemi head.

Bringing the chamber volume down like that, with no change in the piston (i.e. they stayed with flat tops), bumps the compression up.
(from the stock 9:1 to about 10:1. That's the sole performance gain of a Lightning head)

The problem with those heads was the way in which they added the material. When you just add material to a chamber like that, you shroud the valves.
Looking at the chambers, you see a whole lot of material around the valves. That obstructs low lift flow.

Thunderstorm Heads

Two years after the Lightning head, HD came out with the Thunderstorm head.
In the Thunderstorm, they went back to 67cc , allowing them to unshroud the valves and a 15° cast in squish shelf.
They paired it with a domed piston to get the compression up to 10:1.
They also improved the ports and went to larger valve sizes (1.810” / 1.575“). This setup is head and

shoulders better than the Lightning setup.

The angled squish bands direct the fuel being squeezed out of the squish bands more directly at the flame front. [17)]
But the way it's done in the Thunderstorm, it's really rough. Since it's cast in, it's uneven.
Typically from the factory the clearance is .050” or more, and that makes the squish band largely ineffective anyway.

Thunderstorm heads are obsolete now.
They could be machined nice and even, but there's a huge overhang around the perimeter.
So to machine it, typically .035“-.045” had to be taken off the deck, sometimes more.

Below is an example of before and after machining. This is much better with a nice even and consistent squish clearance.
But cutting the deck this much has some side effects, like less valve to piston clearance.
As well as potentially forcing the customer into short or adjustable pushrods.
It also typically makes the chamber too small, forcing us to open it up in other areas.

Also notice how there's not a whole lot of surface area. This squish band is effective up to about a .125“ tall dome.
Anything higher than that and the dome goes past the squish band.

Stock Thunderstorm Heads [18)]	Thunderstorms as Machined [19)]
	

Buell XB/04XL Heads

As delivered, they have flat squish bands with a 62cc chamber. [20)]
This lets you toss them on over flat tops and have a squish band with lots of area and 10:1 compression.
Not a bad way to do it.
If you want to angle it, it's not a problem, you've got lots of material to work with.
You can make the squish band as big or small as you want.
You can make it match the piston you're using exactly, do relief cuts with the rest of the material to help

overlap flow if you want.
You can do all this without excessive deck milling and all the problems that come with it.

The stock valves are the same sizes as the Thunderstorms, 1.810” intake and 1.575“ exhaust.
The springs and guides can support up to .550” lift safely, though, versus .500“ for the Thunderstorms.
The ports are actually a little better than the Thunderstorms.
The Thunderstorms were a major step forward from the Lightning/Screaming Eagle heads, but the XB/04 XL1200 heads are even better.

Stock Buell XB Heads [21]	Machined XB Heads [22]
	

Compression Ratio

Since the beginning of the Sportster line, Harley Davidson has changed head gaskets as way of changing or adjusting compression ratio.
Some were lowered for gas mileage / EPA or raised for performance.
The first thing usually thought of is to change the piston and/or head type to change the compression ratio.
Then you can fine tune with gasket thickness.
However;

> Three tenths of a point in compression isn't really worth your time to tear it down. What's more, just the tolerance is greater than that. [23]
> In other words it's entirely possible your motor is already 10:1 or higher and likewise it's possible it's already 9.4:1 or lower.
> There's variation in every one of the dimensions and volumes that determines compression ratio.
> And the 9.7:1 etc. they advertise is just a nominal number, it's somewhere around there.
> Measuring it really accurately involves several measurements, or alternatively, a volume measurement while the piston sits at TDC which is actually the most accurate way to do it. But it involves sealing the rings, typically with grease, so the liquid used to make the measurement doesn't just flow into the crankcase, and you'll also need a burrette to control and measure the volume of liquid introduced.

> My advice would be to not worry about the exact CR so much (few people do).
> But if you want a worthy reason to go into it and make it better, look at optimizing your squish clearance instead.
> That will increase chamber turbulence (and thus efficiency) and bump up your compression a bit and actually reduce detonation in the process.
> Thin gaskets are an excellent way to do that.
> With N4's, stock pistons and dropping the top the typical .030” or so to get a real good squish clearance, you most likely will not cause yourself a clearance issue.
> Personally I'd check it anyway.
>
> If you want to understand the relationship between gasket thickness and compression ratio, it's not that hard to do.
> Let's say for example that your motor is 10:1 and each cylinder is 600cc (round numbers just to keep it simple).
> That means that at BDC, there's 667cc above the piston and at TDC, there's 67cc above the piston:
>
> - 667 minus 67 = 600cc of displacement
> - 667 divided by 67 = 10:1 compression ratio
>
> Now let's say you've got a .050“ head gasket in there, and it's I.D. is 3.550”.
> You can calculate it's contribution to the volume using the formula for cylindrical displacement, pi x r squared x h:
>
> - 3.14 x 1.775 x 1.775 x .050“ = .495ci, multiply by 2.54 cubed to get 8.11cc
>
> So let's say you go to a .025” head gasket. That 8.11cc will be cut in half to 4.06cc, right?
> So what does that do to the CR?
>
> - 667cc at BDC minus 4cc = 663cc
> - 67cc at TDC minus 4cc = 63cc
> - 663cc divided by 63cc = 10.52:1
>
> So in this example, taking .025“ of thickness out of the head gasket bumped the cr about half a point.
> \\

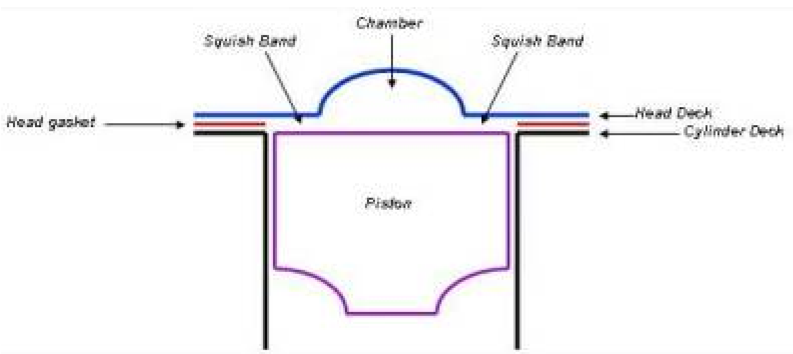
You can also click here to download a compression ratio calculator from NRHS Performance.

Effects of Deck Height

In general, deck height has nothing to do with the squish band.
In the example below with a 3-9/16” bore and the chamber is about 3“ in diameter.
Since you have a 3” diameter chamber over a 3-9/16“ diameter bore, the head deck overhangs the bore by a little over 1/4” all the way around.
Notice how the piston is a flat top for a little over 1/4“ around it's perimeter. That's not an accident.

If you look at the drawing below,
You can see that cutting more off the deck isn't going to change the clearance between the top of the piston and the head deck.
To change that clearance, you've got to use a thinner head gasket, or mill the top of the cylinder so the piston sits higher in it.
(or use a thinner base gasket which accomplishes the same thing)

24)



25)

However, there are situations where decking the head does change the squish clearance.
Look at a Thunderstorm or Lightning head with their angled shelf and massive overhang for example.
In the pic below, you see it's got a cast-in squish shelf. That shelf is angled, and the heads were paired with a piston that had a matching angle.
But see that big overhang around the perimeter of the chamber?
If you deck this head, you reduce or remove that overhang. That most definitely changes the squish clearance.
So there are situations where decking does change the squish clearance and situations where it doesn't.


[26]

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[1] http://www.hammerperf.com/ttcheckingsquish.shtml

[2], [11], [25] drawing by aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/160330-squish-band-clearance?t=1720575

[3] drawing by aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/89229-conversion-using-used-parts-where-to-go-from-here?t=715370

[4] drawing by Hippysmack

[5], [24], [26] photo by aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/160330-squish-band-clearance?t=1720575

[6], [8] photos by JohnK of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-motor-top-end/132786-fixing-a-leaky-top-end-with-pics/page6#post2887799

[7] photo by JohnK of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-motor-top-end/132786-fixing-a-leaky-top-end-with-pics/page6#post2887799

[9] aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-

motorcycle-engine-conversions/167919-883-to-1200-1250-conversion/page3?t=1802811&page=3

[10], [12]

drawing by aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/167919-883-to-1200-1250-conversion/page3?t=1802811&page=3

[13], [14], [15]

photo by aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/167919-883-to-1200-1250-conversion/page3?t=1802811&page=3

[16]

aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/89229-conversion-using-used-parts-where-to-go-from-here?t=715370

[17], [20]

aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/1572-questions-about-buell-upgrade?t=2206

[18], [19], [21], [22]

photo by aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-engine-conversions/1572-questions-about-buell-upgrade?t=2206

[23]

aswracing of the XLFORUM https://www.xlforum.net/forum/sportster-motorcycle-forum/sportster-motorcycle-motor-engine/sportster-motorcycle-motor-top-end/123881-bumping-stock-compression-to-10-0-1?t=1230012