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REF: General-MSR 32

Engine Initial Start-up, Heat Cycles and Break-In

- Using an Oil Pressure Gauge During Initial Start-up:
- Whether you plan to mount an oil gauge on your bike permanently or not, it's a good idea to have one in line for heat cycles and engine break-in. Sure the oil light will come on if your running dry…or will it? A gauge will let you know that the oil pump is working/ pumping oil to your engine during initial start-up which is a crucial time to know especially if it's not.

Heat Cycle

- This is meant as an informative on the subject of heat cycling, nothing more and nothing less. [1)]

What is heat cycling?

- Heat cycling an engine upon initial start-up from a fresh build is a process of heating up and cooling down the engine's internal parts in stages to help insure mating/ sealing of the piston rings to the pistons and cylinder walls. This is a much debated topic in which no actual proof exists or has been published to the nay-sayers of this practice. You won't find it published in the FSM (some say that's because it's done at the factory before the bike leaves). [2)]
- Micro welding is caused by excessive localized heat created when new rings are wearing in on a freshly honed cylinder wall. The highest part of the ring touching the highest part of the wall will create localized friction and heat until the rings have seated completely. The primary consequence of micro welding is loss of performance due to poor ring to land seal caused by micro welding. Other consequences may also occur. [3)]
- Heat cycling your engine in some form or another is published and condoned by cylinder manufacturers and is an integral part of their published initial startup procedures to help prevent micro-welding of the rings. Consequently, if you do not heat cycle upon initial startup, you may be leaving any warranty from them in the trash can.
    - Lugging or running engine prematurely at high rpms may result in damage to pistons and/or other engine components. S&S® voids its guarantee if engine is not broken in properly.

Is this just for EVO engines?

- More people recommend this procedure for EVOs, especially most cylinder manufacturers although some do recommend it for all engines as well.
    - EVOs have a cast iron lined, aluminum bodied cylinder which is sandwiched between the heads and the case with long bolts. The heat transfer differences in the different metals are of concern as they have different rates of expansion and contraction. Aluminum also deforms at a much lower tensile strength that iron, and also at a much lower temperature than iron. When you start an Evo, you've got a cylinder that “grows” at one rate, a liner that “grows” at another rate, and studs that grow at an even “different” rate. [4)]
        - But, in discussing heat damage, aluminum has about 3X the thermal conductivity of iron. [5)]
- Ironheads are a solid block of metal but the new rings even in a seasoned engine need to mate to the cylinders as mentioned.
    - Ironhead cylinders are 100% homogeneous ferrous alloy castings. The whole cylinder has the same rate of expansion and contraction and the cylinders bolt solidly to the crankcase . [6)]
        - Neither new rings nor freshly honed cylinders are perfectly round. That means when you put them together, the rings are only touching the cylinder walls in a few places. The pressure gets concentrated in those spots. That makes the rings get very hot in those localized spots….. It's even more critical with full iron cylinders….There's nothing magical about the bike being an Ironhead that changes the laws of physics. [7)]

Heat Cycling PROS:

- In theory, heat cycling also extends the longevity of your engine.
    - The faster the rings seat, the faster the heat transfer is controlled. During break in, the rings cut their way into the cylinder walls until fully mated all the way around. Since the rings and cylinders are not perfectly round, only various contact points are reached by the rings initially. These points become hot spots since the full ring is designed and needed to transfer the heat prescribed properly instead of just a few spots here and there. This is also true for a re-ring job as well. The new rings have to mate to the seasoned cylinders. These hot spots can lead to a condition known as micro welding.
        - All moving parts in an engine also have to mate together in the process of break in such as bearings, bushings, thrust surfaces, rocker arms, valves, etc. There are many factors that determine cylinder health and life and controlling heat is certainly high up there. The faster the rings seat, the faster excess heat from ring hot spots subsides. Of course there are other factors than just ring seat causing excess heat on startup like quality of machining processes used (boring, honing), engine oiling, quality of the build itself, quality of parts used, engine compression, engine timing, tuning, proper cooling and etc.
- The idea of heat cycles is to “wear down the high spots in a ”“”controlled”””“ manner. [8)]
- It's an exercise to limit excessive temperature by limiting the amount of heat build-up during the first few minutes of operation as the rings begin to lap themselves in. [9)]
- Like it or not, you are heat cycling every time you start a new engine, shut it off and let it cool before you ride it again. Therefore, it is impossible to not heat cycle a new engine. [10)]

- An unfired rebuilt engine has all kinds of torsional, tensile, and compressive stress stored in its metal, I can't think of anything better for an engine than slow, progressive heat cycling as you break it in. If the same process aids in eliminating micro-welding, and it appears it would, all the better. [11)]
- The heat cycle is good because you don't subject a new build motor to extreme heat. [12)]

From Manufacturing/ Vending:

- Ring seal and its effect on engine output cannot be overstressed. The rings have two sealing responsibilities: the cylinder wall and the piston groove. We have seen power jump significantly by replacing the pistons and rings and restoring the bore integrity. Sometimes the pistons looked fine but the ring lands had been damaged during break-in due to heat. [13)]
- The idea of heat cycling is not to treat the metals, it's to give the rings a chance to carve the cylinders into their shape, such that the tension gets evenly distributed and you avoid hot spots. That's what ring seating is. Heat cycling and gentle break-in is all about preventing things from getting too hot until the seating occurs. [14)]
- From S&S Cycle on a new S&S engine: For the initial startup, a baseline calibration for a T143 should be downloaded to the ECU (a base Powervision tune file is available from the S&S website) This is adequate for the initial start-up and heat- cycling of the engine. [15)]
    - For S&S Stroker Kits:
    - Break engine in using following procedure: On initial engine startup, don’t just sit and idle motor while you admire your work, or tinker with minor adjustments. Heat buildup can be excessive. First 50 miles are most critical for new rings and piston break-in. Most engine damage will initially occur during this period. Keep heat down by not exceeding 2500 rpm. Vary speed. Do not lug engine.
- Revolution Performance website doesn’t mention anything about heat cycling although they may do it there before shipping. But, they ship their engines dry so that doesn’t sound like it’s been run. They do say this: After passing all of our quality tests, your engine is covered by our Limited Warranty. [16)]
- From NRHS: Run the bike for 1 minute, then shut it down and let it cool completely. Then run it for two minutes and let it cool completely. Then repeat for 3 and 4 minutes while letting it cool completely between intervals. Next, take it for a 20 mile ride and let it cool completely. Heat cycles are now complete.[17)]

Heat Cycling CONS:

- Arguments against the practice of heat cycling range from builder’s ideas that:
    - General instructions are written for ham handed mechanics and do not apply to ‘real or good mechanics’, [18)]
- Discounting the practice as:
    - Un-necessary and a waste of time for an ironhead [19)]
- Never did before. Why now?:
    - I've rebuilt lots of engines and never heat cycled anything [20)]
- Car engine manufacturers don’t do it:
    - My buddy worked at a gm plant for 30 years. He said they fire em up and give em hell. No

gentle nothing [21)]

- It's only relevant to EVOs:
  - The evos have very tight tolerances in comparison, if that is the issues in there break in cycles…… No heat cycles in Iron head here. NEVER ever had any issues. even in race motors. after running and moving up down in rpm cycles, after cool down just check bolts and torque / nothing out of ordinary. [22)]
- It seems to me that any instructions for modern engines [S&S, Ultima, Evo, automobile, truck, snowmobile, boat, etc] do not apply to IronHead engines. [23)]
- It's a maker's CYA clause and nothing more: Heat cycling is made by lawyers to keep Business from having to replace stuff due to any number of issues. heh, IT was the lawyers that wrote the Warranty info after all… [24)]
- If you employ the most modern machines and best talented machinists, your cylinders will be perfectly straight, rings will automatically seal since the cylinder roundness perfectly matches the ring roundness:
  - Read my post in the importance of torque plates, honing finish and straightness of the bores…. What were acceptable machining practices 25 years ago, [IE honing plateaus, [roughness]], still followed today, will almost guarantee ring damage and a decrease in engine performance and running life…..it's not how you break it in..it's how the engine was built. [25)]

From Manufacturing/ Vending:

What's the best way to break in a new engine?

- The short answer: Run it Hard! Why? Nowadays, the piston ring seal is really what the break in process is all about. Contrary to popular belief, piston rings don't seal the combustion pressure by spring tension. Ring tension is necessary only to "scrape" the oil to prevent it from entering the combustion chamber. The ring exerts maybe 5-10 lbs of spring tension against the cylinder wall …
  - How can such a small amount of spring tension seal against thousands of PSI (Pounds Per Square Inch) of combustion pressure? Of course it can't. How do rings seal against tremendous combustion pressure? From the actual gas pressure itself! It passes over the top of the ring, and gets behind it to force it outward against the cylinder wall. The problem is that new rings are far from perfect and they must be worn in quite a bit in order to completely seal all the way around the bore. If the gas pressure is strong enough during the engine's first miles of operation (open that throttle !!!), then the entire ring will wear into the cylinder surface, to seal the combustion pressure as well as possible.
    - The Problem with "Easy Break In" … The honed crosshatch pattern in the cylinder bore acts like a file to allow the rings to wear. The rings quickly wear down the "peaks" of this roughness, regardless of how hard the engine is run. There's a very small window of opportunity to get the rings to seal really well … the first 20 miles! If the rings aren't forced against the walls soon enough, they'll use up the roughness before they fully seat. Once that happens there is no solution but to re hone the cylinders, install new rings and start over again. [26)]

Should you perform Heat Cycles on your bike during initial startup?

- So far there seems to be a lot of evidence that micro welding of rings can occur and while there are many different “variables” in play here, the only safe assumption is it's best to be on the safe side with heat cycling and proper break-in. With different types of engines, machining, assembly practices needing more care at initial startup than others. [27)]
- And, once again, if your installing new cylinders and you require the warranty, do as the manufacturer asks you to. [28)]
- Heat cycling is more of a performance trick rather than a build standard. [29)] And, in fairness to all, I might add that definition (while seemingly accurate) may be the root of the problem since it doesn't take a performance trick to make an engine run. While the fact that it may take a performance trick to make it run well is subjective to the builder/ owner especially without the smoking gun that everyone seems to be looking for. Without that smoking gun, a builder's belief and reason system is tested and not any builder I've ever met likes to change his opinions very easily, especially from things he's practiced for years.
- We all have our methods, techniques, and beliefs based on what we have experienced. That is a good thing, because it allows the creame to rise to the top. Nothing begats believers more than success. [30)]

This topic is a compilation of several XLFORUM threads on heat cycling:

- http://xlforum.net/forums/showthread.php?t=1501831&highlight=heat+cycle
- http://xlforum.net/forums/showthread.php?t=1794806&highlight=heat+cycle
- http://xlforum.net/forums/showthread.php?t=1969636&highlight=heat+cycle

Ring Micro-Welding:

Manufacturers and Industries alike condone the practice of Heat Cycling as a deterrent against micro-welding. Micro-Welding between rings and pistons are not a myth. [31)] It is defined as adherence of sporadic particles of aluminum from the piston to the bottom side of the piston ring by SAE (Society of Automotive Engineers). [32)]) Several other things can also cause micro welding, such as improper taper on face of ring, improper ring tension, improper ring material, improper clearance, improper assembly procedures/specs and clearances, improper assembly lube, improper initial tuning, improper initial break in. Too much surface contact between a new ring and perfectly smooth bore can cause excessive friction and heat. [33)] piston lands too high on pistons on HP engine, improper clearance between ring and groove in cylinder, or incompatible materials with different coefficient of expansions. Piston and or rings got too hot from lean AF mixtures, timing too advanced, getting them too hot too soon can also cause it. [34)] The variables are so vast, even SAE concedes that because of the variables at large in normal settings, it is difficult to find the proof needed to get a better handle on the subject. [35)] So, SAE did a lab test and produced micro welding in a six cylinder high output 2 stroke water cooled engine in 30 minutes with silicon aluminum pistons and treated ductile iron rings running at 5,200 RPM and no break in time using an accelerated bench test in 1996. [36)] No other evidence of testing for micro welding of rings has been found to be done by SAE. Obviously, proper heat cycling will not prevent micro welded rings when a multitude of other problems exist. [37)]

Breaking In Your Engine:

- In breaking in a new engine, you might hear from other owners how they tested their rev limiters, rode it fast and hard for however many miles or purposely stayed in stop and go traffic to simulate heat and cooling cycles. Just follow the MFGs recommendations from your owner's manual [38)] and you'll be fine. These are common instructions that are given to every new bike owner. It's just an easy way to say keep the heat down. [39)]
- Generally speaking, main thing is dont over rev it, dont under-rev and lug it and dont overheat it. [40)]
- An engine is said to be broken in by the first 500 miles by the MoCo. [41)]but for the first 50 miles, keep speed below 45MPH. For the first 500 miles, vary your speed, avoid steady speed on long distances and keep it under 60 MPH. FSM and Clymer are pretty much in agreement on this paragraph.
- Proper warm up is also imperative. Along with proper break in and getting in the habit of allowing the motor to warm up properly before any ride will go a long way in giving you years of trouble free performance. [42)]
- Before changing exhaust and/or other mods that could change the air/ fuel mixture or exert different than intended pressures on the engine, break it in first, then pay your Harley tax. [43)]
- Change Oil during and after break-in. The motor will put lots of metal in the filter in the first couple of hundred miles. [44)] Dino (mineral based) oil is the widely accepted type of oil for use in breaking in a new engine. You may want to change oil and filter several times during break-in if you like. It won't hurt anything but it's recommended after the first 500 miles. After the first 2,500 miles, you can swap to synthetic oil if you choose.
- Noises during break-in: Keep the little stuff adjusted and fluids topped off. Run a good brand of gas and keep the revs within a good range without bogging it. [45)]. Sportsters are noisy….If she sounds like a sewing machine with dual exhaust, you're fine. [46)]
    - There may be noises of the different parts trying to mesh together, lifters may be noisy until fully pumped up ,etc. If engine noises persist, see engine_noises in the troubleshooting section.

- When breaking in aftermarket cylinders, conversions, it's best to follow the manufacturer's procedure for breaking in their products to ensure the accompanying warranty from them. This information is usually sent along with your kit from them.
- Engine break-in has been described as " the final machining process" and is an important part of ring sealing, performance and longevity of your engine. Most manufacturer's recommend to heat_cycle the engine first.
- Stay under 3,500 RPMs and keep air moving for the next 500 or so miles.
- Avoid WOT
- Avoid long distance steady RPMs.
- Use a good quality 20W50 oil.
- After the first 500 miles or so, let er rip.

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[1)] , [2)] , [28)]
hippysmack from the XLFORUM

3)

Matty from the XLFORUM

4) , 6)

Rivethog from the XLFORUM

5) , 7)

Aswracing-from the XLFORUM- vendor/ Hammer Performance

8)

DR Dick from the XLFORUM

9)

Tom Beckner from the XLFORUM

10) , 27) , 33) , 34) , 37)

XLXR from the XLFORUM

11) , 30)

56KHK from the XLFORUM

12)

rejeanprimeau from the XLFORUM

13)

http://www.axtellsales.com/files/PDF-files/Ring-Seal.pdf

14)

aswracing from the XLFORUM- vendor from Hammer Performance

15)

http://www.sscycle.com/files/2714/3197/7873/510-0293_T2_T143_20150518.pdf

16)

http://www.revperf.com/engineRebuild.php

17)

http://www.nrhsperformance.com/NrhsInstructionSheet.pdf

18) , 25)

hcrashster from the XLFORUM

19)

rivethog from the XLFRUM

20)

ericfreeman from the XLFORUM

21)

AnaChris from the XLFORUM

22)

tracbike from the XLFORUM

23)

IronMick from the XLFORUM

24)

Levi Luther of theXLFORUM

26)

http://www.mototuneusa.com/break_in_secrets.htm

29)

einheit 13 from the XLFORUM

31)

norseXL of the XLFORUM

32) , 35) , 36)

http://papers.sae.org/960745/

38)

NRHS Sales http://xlforum.net/forums/showthread.php?t=1748326&highlight=engine+break+in

39)

ReddTigger http://xlforum.net/forums/showthread.php?t=1748326&highlight=engine+break+in
[40]

Hopper http://xlforum.net/forums/showthread.php?t=390897&highlight=engine+break+in
[41]

1998 HD XLH FSM
[42]

Desertfox http://xlforum.net/forums/showthread.php?t=1748326&highlight=engine+break+in
[43]

papas http://xlforum.net/forums/showthread.php?t=1573751&highlight=engine+break+in
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[45]

sportysrock http://xlforum.net/forums/showthread.php?t=26029&highlight=engine+break+in
[46]

cantolina http://xlforum.net/forums/showthread.php?t=26029&highlight=engine+break+in