

# *Zero Friction Cycling*



## Lubricant On Test : Muc Off Nano

Cost: \$106.50 Aud from Muc-Off (inc. Postage)

Size – 50ml



Photo :

### Manufacturers Description on package;

Created using cutting edge, intensive R&D, our Nanotube Chain Lube will give you many miles of ultimate speed in all weathers.

This formula will allow you to achieve significant wattage savings over traditional lubes. This new, state of the art formula pushes the boundaries of chain lube innovation and is designed specifically to keep friction to an absolute bare minimum over a long period in ALL weather conditions.

The unique graphite like layered structure of carbon nanotubes, which have exceptional high strength and low density, make the ideal for use in a lubricant. Significantly reducing friction on any moving part, they are so small they can penetrate deeply into each chain link to create a super smooth and highly durable friction reducing layer.

## Directions on package

First time user – Fully de-grease and dry chain. Shake bottle vigorously and apply lube ensuring every part of the chain is treated. Apply 3-4 hours before your ride. Wipe off excess with a cloth. Avoid contact with brakes. Store in a cool dry place

## Extra information from Manufacturer website

Note there is none listed directly for the bottle of lube, as this is a top up lube for the NTC / Nano chain. It is important to understand the couple of different product levels here with Muc off – They have their Nano Chain which is very expensive – this chain is broken in prior to US cleaning and treatment with I believe this Nano Lube. And there is the NTC chain which is their newly launched chain, and this is not broken in but goes straight into US cleaner and then treated with Nano lube, and requires users to “run in” for 4 to 6 hours on turbo trainer to reach peak performance. The Nano lube on test here (as best as I can ascertain from Muc-Off) is the super lube used for both chains. Here are the claims re NTC chain from Muc-Off; *\*However please note the watts savings claimed over Ceramic Speed UFO chains are I believe – in the strongest terms possible – to be completely incorrect. A fair bit of detail is provided around this is a bit later – and for more detail please do not hesitate to send me an email + read the open letter response from Ceramic Speed etc. If you have time for neither – then I can only hope you trust my belief and understanding of testing, my own experience and thousands of km’s of testing – and honestly – a bit of logic that many things on many fronts with the Muc Off testing just do not pass muster. They spruik claims and testing that looks and sounds amazing on the surface, but quickly falls apart under scrutiny. Anyway, please find in my humble opinion the most fictional marketing claims I have ever seen attached below;*

Proving savings of over 10 watts\* against Ceramic Speed’s Shimano Dura-Ace UFO Chain over a race distance on our dynamometer, the NTC is the culmination of thousands of hours of research and development into drivetrain optimisation.

To create this revolutionary product, we sonic cleanse a Shimano Dura-Ace chain and then hand treat it with a proprietary nanotube formulation. Once in the hands of the customer, it simply needs to be run-in on a turbo for 4-6 hours before it reaches its optimum lubrication state.

What makes the NTC so special is its ability to deliver wattage savings consistently over long periods of time and in all weathers. Other chains may claim to be 'the fastest' but what they don't tell you is for how long and in what conditions.

A major finding to come from Muc-Off's Development House was the shorter durability of Ceramic Speed Shimano UFO Chain. Whilst efficiency of this product was admittedly quite good in the first few minutes, registering at around 4.5 - 5 watts, this performance rapidly deteriorated after only 18 minutes!

In comparison, the NTC only continues to get faster, with over 10 watts advantage against Ceramic Speed's latest treatment UFO Shimano Chain after four hours. In performance terms, this means that the NTC will give you a gain of 3 miles over a 112- mile Ironman bike stage, calculated using the average time of 6 hours and 25 minutes.

Unlike other optimised chains currently available in the market, the NTC maintains its performance in all-weather conditions.

## **Any extra detailed information re application and usage from website;**

Nil extra info re application. Note however for this test I initially applied ultrasonically with chain fully submersed.

Clean Chain Efficiency rating: According to Muc off it will be around 4w.

Viscosity: Thick – 1ml moved 4.0cm in 10 seconds on 30dg angle.

*Test stops when net chain wear reaches 0.5mm+*

## Muc-Off Team Sky Hydrodynamic Main Test Results

Block (each 1000km)	Wear measure (mm)	Inc. On previous measure	% Wear for block (0.5mm=100%)	% Wear rate per 100km	Comments / Observations
0 – Initial check measure	0.117	n/a	n/a	n/a	Shimano chains usually measure 0.1 to 0.15mm from new.
1 – No contamination	0.306	0.189	37.7%	3.77%	A simply astounding clean block 1 wear rate. Penetration issue from high viscosity lube not a factor as was ultrasonically applied. The highest wear rate for clean block 1 of any lubricant test by a huge margin.
2 – Dry contamination	0.844	0.539	107.7%	10.7%	Again nothing has ripped through a chain like this before – with an accumulative wear of 145.4% in just 2000km – it is literally hard to fathom this wear rate.
3 – No added contamination	n/a	n/a	n/a	n/a	Not tested as already at 145.4% wear allowance at end of block 2.
4 – Wet contamination	n/a	n/a	n/a	n/a	Not tested as past wear allowance.
5 – No added contamination	n/a	n/a	n/a	n/a	Not tested as past wear allowance.

Extrapolated wear based on blocks 1-5 = 1375km

### Extreme Contamination Block (chain cleaned again prior to test)

Start wear measure	500km measure	1000km or end of test measure & km	% Wear for block (0.5mm=100%)	% wear rate per 100km	Comments / Observations
n/a	n/a	n/a	n/a	n/a	Not tested due to previous wear rates.

### Single Application Longevity test (Chain Cleaned Prior to test – no added contamination – Cumulative wear checked every 250km) – allowed extra 0.25mm on top of end of block 1-6 wear measure

Start wear measure	% wear 250km	% wear 500km	% wear 750km	% wear 1000km	% Wear 1250km	% wear 1500km	
n/a	n/a	n/a	N/a	N/a	N/a	N/a	Based on block 1 and 2 results there was no point to test single application longevity.

## Test observations and review

I find Muc-Off to be a most perplexing company. Their marketing is amazing. Reading their NTC launch brochure most readers would finish with an impression that;

- >A huge amount of R&D goes into their products from a world leading test lab.
- > The results from the test lab have to be bona-fide as the products are going to Team Sky – a data driven team that requires the products to be able to quantify and prove their performance
- >Other manufacturers testing should be discounted
- >Team Sky Hydrodynamic helped power them to 4 Grand Tour victories
- >Nano chain, NTC chain, and Nano lube are products derived from the huge R&D put into the lube developed for Bradley Wiggins hour record.

Now I am big on testing and data and for manufacturers to be backing up big claims with said data to prove these claims. I find it very frustrating the number of manufacturers releasing lubricants that make huge claims re performance and yet provide no data or information that sits behind the claims – and I find it even more frustrating when one writes to manufacturer with questions regarding the claims, the testing that was undertaken to ascertain - test data / protocol / results etc – and one gets back nothing. To me it makes no sense – if I had spent a huge amount of time, dollars and effort and made a truly great product, and a potential customer asked me about it, you could rest assured they would get some info! In fact just try and stop me talking about it to anyone / anywhere that will listen.

Muc Off are very keen to talk about their testing in very carefully crafted and worded marketing brochures, but proving less so with specific questions on their testing and data and protocols.

The performance of this lube is linked with current testing controversy between Muc Off and their NTC (Nano Tube Chain) launch and Ceramic Speed UFO chains and UFO drip lube.

For those not familiar – Muc Off launched NTC chain, which showed friction efficiency performance starting at around 4w, and finishing at 3.8w after 4 hours. It showed a number of competitors degrading in performance quite badly, most notably Ceramic Speed UFO which started to show a notable degradation in performance after just 18 minutes, and 10w drop after 4 hours. Hence the big shouting in the Muc Off advertising about a 10w benefit vs UFO chain.

That is a huge performance difference claim. And so I need to cover this topic a bit here before moving to the test results and lube review.

Firstly – let us just take a short moment to ponder what this claim means. 10 watts greater friction performance – that is MASSIVE. Can you imagine any lubricant you can think of that could increase in friction by 10 watts after just 4 hours of running. In a lab. So taking to the real world – even if you were quite a gun rider and could average 40kmh, could you find a lubricant that increased in friction by 10w after just 160km of riding?

It would be a tough challenge indeed. That is an enormous increase in friction in such a short time. Such an increase in friction would also result in rapid wear of chain.

Now think about the odds that the top level lubricant from Ceramic Speed – developed by Jason Smith of Friction Facts – would suffer a 10w drop over 4 hours.

Also try to imagine any lubricant that starts to have a notable degradation in performance after just 18 minutes. And again apply these odds to the top billed lubricant from Ceramic Speed.



The superfast waxes, which are paraffin based with added PTFE, Molybdenum and other “friction modifiers” such as Molten Speed Wax and UFO wax would likely be the most tested bicycle lubricants on the planet.

Jason Smith of Friction Facts – and now Ceramic Speed, plus John Thompson of MSW *who credits Jason with the formula for his company's product* - didn't just wake up one day and decide that their life's mission should be to grab some paraffin and prove to the world that it is an amazing bicycle chain lubricant. It just so happened that when Jason Smith tested paraffin during FF testing the result was extremely surprising. So much so initially he thought something was wrong with the test machine.

After much investigation into friction producing mechanisms in a chain he published an excellent white paper on this which is on the FF website and explains the performance result behind paraffin. As it proved such a great lubricant for bicycle chains, it was simply a great base to play with various additives and “friction modifiers” to see if the performance could be further improved – and thus after no doubt much fun in white lab coats later – we have amazing products like UFO and Molten Speed Wax.

Aside from outright efficiency, immersive waxes which then set to a solid have some inherent advantages vs liquid lubricants on a part working completely externally, exposed to contamination and the elements. These advantages have been tested and proven in both lab and a huge amount of real world ride testing from Road to Mountain Bike to CX. No lubricant known is as resistant to friction increases from external contamination, and therefore remaining as close to lab performance until treatment is worn off as solid immersive wax product treatments.

It is important to note that wax based drip lubes are not immersive waxing. Many will have tried a wax lube and found it rubbish, because it was rubbish – and then attributed its poor performance to everything wax. There is a lot of myth and misconception regarding lifespan and performance in harsh conditions of wax. A wax drip lube may be 20% wax and 80% carrier fluid, have poor penetration to pin due to heavy viscosity, not set dry but goes tacky and sticky, and so for many reasons may deliver a short lifespan and poor performance. This has absolutely no bearing at all on the performance of a chain treated by way of full immersion in a superfast wax blend that has every square nanometre inside the chain completely coated, which then sets to an actual proper solid for outstanding resistance to grabbing and holding abrasive contamination.

It is akin to buying a red Mitsubishi Magna and then declaring that all red cars are crap. A few red Ferrari's would take issue with being tarred with the same brush. (Apologies to any Magna drivers who take offense ☺).

So back to the Muc Off testing.

What is most definitely known is that no wax, nor likely any chain lubricant – starts to show a notable drop in performance after just 18 minutes, and a 10w drop in friction after 4 hours. Concerns were held that the testing completed by Muc-Off was performed incorrectly by way of running the chains on a “Full Tension Test” machine for the entire 4 hour test time - which for many lubricants can produce an anomalous result. A full tension test machine looks a bit like a track bike - just one chain ring and a rear cog – however the difference is “tension” is introduced into the chain by way of a heavy weight pulling rear cog back to tension the chain to simulate a 250w load. This places the chain under same high tension on top and bottom sections of chain in the drive train. This is unlike a traditional bicycle drive train where the chain “slackens” through the bottom part of the drive train. Even with track bikes the chain is under very low load through the bottom of the drive train, and full rider load across the top.

The Full tension test machine is the most accurate way for measuring outright efficiency results for a lubricant / chain. However for many lubricants, if kept running on this machine and so not experiencing “slacking” through the bottom of the drive train, the lubricants molecules are not able to re-align, and after a period of time anomalous friction performance results begin to occur.

The anomalous results for some lubricants undergoing long runs on a FTT machine was covered in a paper released in 2015 by Jason Smith. After anomalous results for some lubricants were noticed during longer runs on FTT machine, he started to investigate what was going on. He noticed that if chains were rested for a bit and then re started, their friction levels had reverted back to what they were at the start of the initial test. Some lubricants would be unaffected by not having any “slacking” or rest time, whereas others are heavily affected. However if run on a test machine that is set up like a bicycle drivetrain, with a pulley wheel system on the bottom allowing chains the slacking effect they experience when riding a real bike– the anomalous friction results did not occur. As such he published a paper with regards to this in 2015 that friction testing by way of long runs on Full Tension Test machine will produce greatly anomalous results for certain lubricants. The correct process is to efficiency test on FTT machine, move chain to an endurance machine / bicycle to run for extended periods / protocols, and then back to FTT machine to check any changes in efficiency.

It is worth noting Muc Off have both a FTT machine and an “Endurance” machine – which is the one set up like a true bicycle drivetrain.

I personally find it impossible to believe that Muc Off are unaware re the anomalous results that are produced for some lubricants if run for long periods on FTT machine, and also that solid wax based lubricants are one of those products. They have an FTT machine and an Endurance machine for a reason.

Prior to Ceramic Speed releasing their open letter response re the Muc Off testing and brochure having UFO wax performance degrading after just 18 minutes and 10w drop in 4 hours – Jason Smith tested UFO wax just on FTT machine – as he had theorised was the case with the Muc-Off testing - and obtained same performance degradation results. The friction resets again when chain is rested. This friction increase is not seen when chain is run on endurance machine (or normal derailleur bicycle), nor on track bikes as they do not have the huge tension put into top and bottom span of chain to simulate 250w load – there is still very low load through bottom of the drive train.

So there are some very important questions about this entire situation regarding the performance claims and testing of lubricants. As a reader / consumer you should ask yourself what do you believe – these are two of the most expensive chain lubricants on the planet and both trying to claim top spot re low friction performance. The first three I would have are;

- Do you believe UFO would start to show a notable drop in performance after just 18 minutes and a 10w drop in 4 hours?
- Do you believe Muc-Off have tested incorrectly by running test for 4 hours on FTT machine only?
- Do you believe Muc-Off are unaware of the anomalous results for some lubricants when run for long periods on FTT machine?

I would then have a couple of supplementary questions;

- Why was further investigation into the results for UFO not conducted? A drop in performance that soon and that large from your main competitors number one product should have raised some eyebrows indeed. Also of note is that in the original brochure by Muc Off it showed testing of UFO timeline across 2 days, and with an 8w recovery from day 1 to day 2. What would cause a lubricant to improve its efficiency by 8w overnight without any cleaning / retreatment? Who – conducting supposedly world leading testing, would just go “meh” and not only plough on – but PUBLISH these test results and rather fantastical claims derived from them.
- Why was this 8w recovery subsequently edited out of brochure? (however original brochure was captured)
- Why in the Muc-Off brochure do they have on one page the amazing performance of the NTC chain starting at 4w and finishing at 3.8w after 4 hours, but then 2 pages later have their own budget c3 Dry lube at 2.9w?

So in the one corner we have Jason Smith – who founded Friction Facts, who discovered that paraffin performed exceptionally well on bicycle chains, played with a bunch of additives and a huge amount of testing later both lab and testing chains after having been ridden in every type of event and conditions. He wrote the book on efficiency testing for chain and lubricants including proving the need for both FTT and Endurance machines. In the other corner we have the above questions regarding Muc-Off testing.

From a personal perspective – I tried Molten Speed Wax many years ago after stumbling across it, and 70,000km+ of my own user experience later – and I race pretty much everything – road, tt, cx, mtb - and have tracked the lifespan of every component of all of my bikes from day dot.

Quite simply – MSW has flat out slayed every liquid lube I have seen. And there are just so many captain obvious logical reasons as to why it does so. It is why it was my number one product when I started Zero Friction Cycling. Immersive waxing isn't for everyone, and it comes with providing a lot more customer support to ensure done correctly. I am not exactly short of highly billed lubricants to choose from to stock and sell. I sure as heck would not have chosen to stock and sell MSW if it wasn't amazing, I would sell and stock other lubes that I had found to be outstanding. I am spending enormous resources to find drip lubricants that are also outstanding to provide other options for customers for whom waxing is not for them, or for events that will exceed waxings treatment lifespan. And the similarities between MSW and Ceramic Speed UFO are obviously very high. In short – I know the performance and limitations of these products extraordinarily well, and find the testing and performance claims of Ceramic Speed / MSW to be extremely accurate. I have great concerns regarding the claims and testing situation with Muc-Off.

Anyhoo – apologies for the long pre amble – however the scene needs to be set somewhat for what is now fairly open warfare of the top very expensive super lubes and chains from Muc-Off vs their waxed based competition. It is good to understand a bit about what the heck is going on with the two vastly different testing performance claims, and make up your own mind as to whom you believe.

If you are still stuck re who to believe – then hopefully you can believe in my testing ☺. The strength of my testing is its simplicity. It is a bicycle drivetrain driven by a 250w motor at 100cadence. Lubricants are applied as per manufacturer's instructions, re-lubed as per instructions, clean blocks and contamination blocks are run with the same controlled contamination introduction for all chains, and wear rates of the chain closely measured to 0.01mm accuracy. Chain elongation wear is wear of hardened steel pins and inner plate shoulders and this is done via abrasive friction. If a lubricant created a frictionless interface between the parts of the chain under direct rider load which are responsible for chain elongation wear, there would be no wear and no stretch. If there is a fast rate of wear – you just flat out cannot eat through hardened steel parts at a prodigious rate without a lot of friction. My tests are run over thousands of km's and depending on performance - well over 100 hours - and is vastly more representative re the performance a rider can expect vs what a 5 min to 4 hour lab test will tell them. (And that is even if the lab tests are not skewed). The wear rates do not lie.

Whilst clean chain clean lab testing shows outright efficiency to an extremely accurate level – where aspects such as viscous friction and stiction play an important part in the outright efficiency result in the lab – this does not help us so much in the real world. As a lubricant becomes more abrasive from contamination the high pressure abrasive friction of full rider load – the friction responsible for wearing down the hardened steel

parts of pin / inner plate shoulders / rollers – this friction becomes by far the greatest % of a lubricants efficiency. (*\*My tests also show if a lubricant has penetration to pin issues, how well it resists or absorbs contamination, how well a lubricant is able to clear gathered contamination etc – which none of the fancy lab tests are demonstrating. My full test protocol is also completely open and the protocol running sheets for all lubricant tests are available on request and have been openly shared to a number of parties*).

And lastly before getting to the test results – A good while ago in preparation for this test I wrote to Muc-Off and asked them re if I was looking for a great DIY race chain and I could not afford the high cost of a Nano chain, could I simply properly clean a new chain and use Nano lube? They replied say yes, it won't be as fast as their Nano chain which undergoes break in and preparation methods to ensure lubricant penetrates completely to all parts of the chain, however using Nano as a drip lube would still provide a great race chain as it is their fastest lube. (*I do however have ultrasonics so believe I can match the prep shown in their video for the NTC chain which simply shows a batch of chains being ultrasonically cleaned and then lube ultrasonically applied*).

I also asked what was the difference between Team Sky Hydrodynamic and Nano lube, and from what I could garner – the Nano lube is Team Sky Hydrodynamic with added nano tubes. For the record having just tested Team Sky Hydrodynamic prior to this test – I can advise they look exactly the same, both a distinct blue with black swirls – you would not be able to tell them apart visually. The Nano lube was slightly more viscous however so there is a difference between the two.

As the Nano lube is designed as a top up lube to NTC or Nano chain – I decided for this test to treat the lubricant as such and to initially ultrasonically apply the lubricant to a perfectly cleaned chain. (*Note – this required me to purchase 3 x 50ml bottles so that I had sufficient lubricant to have chain fully submerged for ultrasonic – at a total cost of \$319.50, so this was one very expensive test!*). When looking at the video for the making of the NTC chain it appears as though they simply do exactly the same thing however on a much larger scale. They have what appears to be an industrial size ultrasonic containing retail 1 billion dollars worth of Nano lube, and stack of chains have lube applied fully immersed. Being a highly viscous lube this application would negate any initial penetration to pin issues as was seen with Squirt / Smoove that was resolved with ultrasonic application. I was also wondering if there was an initial penetration issue with Hydrodynamic due to its terrible clean block 1 wear rate – and so was not taking any chances with a lube designed as a top up lube – so ultrasonically applied at great expense it was.

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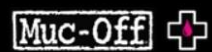
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ZFC Ultrasonic



## So, to the product and ZFC test results.

Ok – so if you read the review for Team Sky Hydrodynamic you would have seen that this lube performed rather horrendously with chain wear rates that were greater than I would have thought possible. It started terribly in clean block 1, however moving to block 2 which has added contamination – which should be entering an extreme conditions lube’s playground – it showed it simply absorbed all particles of contamination and quickly became basically liquid sandpaper. It was also horrendously messy. I put a call out on social media to ask if anyone had used the product and their experience – and the replies were unanimous – it creates a horrible mess, and for those that used more than once or twice (most stopped after that due to the mess), they also notice high parts wear rates.

So – if the nano lube is Team Sky Hydrodynamic with added nano tubes – then the nano tubes had a pretty hard task ahead of them to turn the performance of Hydrodynamic around to something that now thrashes all other lubes on the market. And at \$106.50 delivered for a 50ml bottle – that is the level of performance expected indeed.

Well, it did thrash all other lubes tested to date – but unfortunately it was in regards to record setting wear rates. Rather astoundingly it was even notably worse than Hydrodynamic. I could scarcely believe the wear rates of Hydrodynamic, and the Nano lube had me staring slack jawed at the wear measures coming in. Clean block 1 – remembering it has been ultrasonically applied so it has complete penetration to pin – recorded a wear rate of 37.7%. Dry contamination block 2 – just like Hydrodynamic no particle of grit escapes its clutches – recorded a 107.7% wear rate for the block – resulting in an accumulative wear rate of 145.4% after just the first two blocks. Below are the data tables for lubes tested to date for comparison;

Wear rate per 100km block (not accumulative)

Lube	Block 1 - No Contamination	Block 2 - Dry Contamination
Rock N Roll Gold	8.9%	29.0%
Molten Speed Wax	0.0%	12.0%
Squirt	19.1%	22.0%
White Lightning Epic Ride	22.9%	33.7%
Smooove	19.1%	17.4%
Muc-Off Hydro Dynamic	27.6%	98.9%
Muc - Off Nano	37.7%	107.7%

Also just like Hydrodynamic it was horrendously messy. Apologies for the repeated use of the word – it is simply what best describes both the performance and the mess.

To say I don't understand what is going on with Hydrodynamic and Nano products is an understatement. I have seen no lubricants marketed as aggressively – Refer to their claims re amount of testing in state of the art facilities and all conquering performance in all conditions, developed for the top grand tour team in the world and powering them to 4 grand tour victories.

And yet – apply product to a clean chain and run it on a bicycle drivetrain – and we see wear rates that are just incredibly high. It quickly becomes extremely dirty, and you can simply see, hear and feel it grabbing and holding all contamination. Handling the chain in between intervals and it feels terrible, bend the chain and there is just grit crunching and grinding inside. It sends shivers down ones spine that this what is lubricating a part doing 20,000 articulations a minute.

So in summary I have two very deep concerns regarding Muc-Off.

First is the entire situation with their testing and marketing claims for Nano / NTC vs UFO and this 10w drop for UFO after 4 hours. I know a thing or two about lubes and testing. If UFO / MSW was crap and Nano was amazing, you can rest assured what products would be in my store and what would not. I find it a bit disturbing that the NTC brochure was published. Everything I know from years and years of personal experience, testing and dealings with Jason Smith and his testing – I know the performance of MSW and UFO. Ceramic Speeds open letter response also rather undisputedly explains things. So going to print they are either publishing they test incorrectly, or something even worse.

Secondly there is the performance results for both Hydrodynamic and Nano – which are just..... well there is no way to put it nicely. There is simply no hiding from the wear rates, and what that means regarding friction.

There is one source off clarification regarding the results and discrepancies and that is Muc Off. They have not responded to my last email with questions regarding the results of Hydrodynamic test, as well as questions regarding clarifying use of FTT machine for 4 hours for their lubricant testing despite the known issue of the anomalous results this produces for some lubricants. Also why in their own brochure they have their budget c3 dry lube at 2.9w vs their Nano chain at 4w. I will write to them re the Nano test when I figure out how to word it not too harshly, and re ask all of the above again. They already have all my testing protocol information so are aware of the testing the lubricants are being put through.

Should I get a reply that explains everything, I will of course update this review. In the interim all I can say is that there is no hiding from the test results, the discrepancies and questions regarding their marketing and testing are very concerning, and the silence in response to these questions is in my view not acceptable. Ceramic Speeds open letter response to the Muc Off testing claims raises serious questions, and they should answer them. I would also like to understand the test results I attained – so will follow up further and see how I go...

**Open letter response from Ceramic Speed** - <http://www.ceramicspeed.com/sport/news/latest-news/an-open-communication-on-muc-offs-claims-on-testing/>



A final note to remind again the differences re the Muc Off race chain products.

- Nano Chain – Chain broken in apparently to optimal point – cleaned (no doubt ultrasonically – how many rounds – unknown) – lube applied ultrasonically – believed to be Nano Lube. Very expensive race chain, way above UFO or MSW race chain.
- NTC chain – perhaps sales of Nano Chain a little slow – so a lower price point chain introduced that skips break in, and advises user to break in themselves with 4 to 6 hours of riding on an ergo to achieve optimum performance. Not only is this not super handy – I believe it is also quite naughty. Quite a lot of metal from chain manufacture initially comes off during first rides, which is why break in for race chains is typically an absolute step number one necessity. It is important to capture these metal particles in factory grease and then conduct multiple rounds of ultrasonic cleaning. Not doing this will leave the metal particles running in the lube. This isn't great. You wouldn't sprinkle metal particles on your chain, so neither should you leave them in there. Skipping this preparation step to drop cost but advise customers to run for 4 to 6 hours on ergo – convenience issue aside – I again have severe doubts re the real world performance this is going to deliver. Refer to pic below which is metal fragments from cleaning post chain break in – do you want that running in your lube? You could do a much better race chain prep at home by riding new chain with factory grease for an hour, meticulously clean – and then apply a proven very fast lube of which you have some excellent choices.



So ratings for the moment;

### **ZFC Overall Performance Ratings**

#### **Race Day Lubricant Road – 0/10**

Muc-Off claim 4w for the Nano, moving to 3.8w over a 4 hour period which would be fantast if correct. I saw a wear rate of 37% in clean block 1 which is phenomenally high. That is almost 0.2mm of hardened steel worn through across an 8 link span, or 2.7mm of hardened steel abraded through across 108 links. The lubricant was applied ultrasonically – so there were no penetration issues to pin & inner plate shoulders.

#### **Race Day Lubricant - MTB / CX – 0/10**

I have not seen a lubricant absorb all contamination like Nano and Team Sky Hydrodynamic. It quickly becomes an industrial grinding paste. Over 7mm of hardened steel abraded through in the dry contamination block.

#### **Everyday Lubricant – 0/10**

Extremely expensive, horrendously messy, and practically unbelievable wear rates.

#### **Harsh Conditions Lubricant – 0/10**

It simply does not matter that it is Hydrodynamic and will not be washed off in harsh conditions. What is staying on is providing you with the highest friction performance you are likely to find.

### Single Application for Long event – 0/10

As above. Based on wear rates from block 1 & 2 there was simply no point wasting time and money to do single application longevity test. Wear rates are horrendous even when fully lubricated.

### Cost to lubricate (based on blocks 1-5)

The small 50ml bottles do go a long way, however at \$106.50 per 50ml bottle, the cost of this lube is way above anything else. It needed to be offset by delivering amazingly low friction and parts wear rates, however the exact opposite was seen with parts wear rates well above any other lubricant tested to date. Added together, running Muc-Off Nano as your daily lube is for millionaires only.

### Extrapolated drive train running costs table per 10,000km based on blocks 1-5.

(Cost per km of lubricant & assume 2 x chains @0.5mm wear per cassette & 6 x chains per set of chain rings. Australian online + Lbs store RRP prices of ultegra cassettes and chain rings) .

Lubricant cost per 10,00km	Chains per 10,000km (\$40 per chain)	Number of cassettes worn per 10,000km & cost (\$90 per cassette)	Chain rings cost per 10,000km (\$195 set).	Total Drive train running cost per 10,000km
<b>\$266.25</b>	<b>5 = \$292.00</b>	<b>3.65 = \$328.5</b>	<b>1.22 = \$237.9</b>	<b>\$1124.65</b>

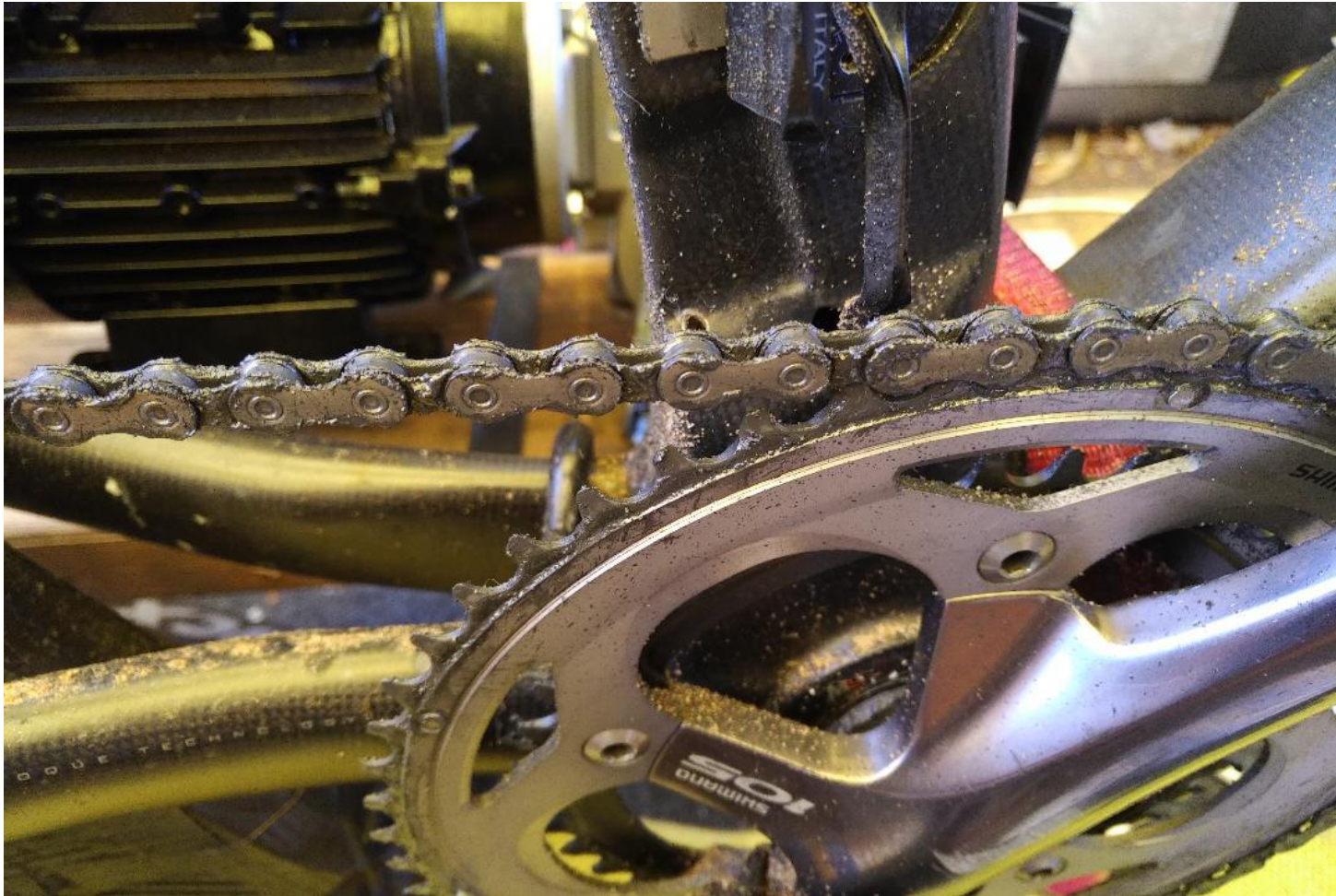
(0.5bottles used for 2000km, 7.3 chains, 3.65 cassetts, 1.22 chain rings.



Pics from test



Post first 400km interval chain wipe. A fair bit of black mess coming off already.



End of main test – 2000km – Not looking good.





End of main test – 2000km – You can see the grit stuck in the gunk build up.





End of test – 2000km mark – It is just messy, messy stuff – the test ending at 2000km is much sooner than most other lubricants and yet the mess level is well ahead of most that went much deeper. You can see the spray on the flywheel. It was also sprayed on crank arm, pedal, and equipment I had in vicinity.



End of main test – 2000km – When I removed the chain to start cleaning, the level of mess was just horrendous. Overall amount of lube used is quite low, approx. half the bottle (25ml). The lube itself is obviously long lasting – you get a lot of km's out of an application, the problem is the huge wear rate. This may give a sense of why every particle of contamination sticks to it.

**Best internet review I found for Muc Off Nano here;**

Unable to find an actual review for Nano lube as it is a top up lube for Nano chains / NTC chains. Have been unable to find any actual user testing or reviews of these chains – all articles are just putting up the marketing claims by Muc-Off.

As far as I am aware ZFC test is the only independent test off Nano. The only other tests are the competing and conflicting information from the manufacturer and their main competitor.

## Lube Logic – Little Compendium of knowledge to save you \$ and lost watts.

In the information below I go through a number of the main claims made by manufacturers, run through a bit of a reality check, and help provide a base understanding re how things may or may not work. Some lubes are getting pretty fancy – and some are VERY expensive.

Does your lube clean as it lubes? Does it form a protective membrane? Does it “condition” the metal? Is it PTFE based, or wax, or mineral oil, synthetic oil, or ceramic tech, or nano tech, or contain laser crafted micro balls? Is it a dry lube? wet lube? What is most important to you – outright efficiency? Longevity? Cleanliness? Cost to run? Do you have different needs for your TT bike vs your road bike vs your cx or mountain bike?

The below should help you make an informed decision on what is the right lube/s for you, and this information will continue to update as our testing reveals actual performance vs claims.

## **Lube testing – what are we looking for and why should you care?**

Your chain is your hardest working part by miles, and it is working completely exposed to dust, grit, water, mud. Friction Facts testing was ground breaking and they really shone a light into the dark art of drive train friction. However, outright efficiency on a clean chain in clean lab environment tells only one part of the story.

Data on lubricant performance once contaminated is extremely scarce - and yet most performance claims centre around how the lubricant deals with contamination – cleans as lubes, forms protective films / membranes etc. They boast about many awesome things the lubricant apparently does whilst you are out riding around in the real world – but where is the testing and data for this?!

Considering that the biggest impact to a lubricant and therefore a chains performance is contamination, and that all chains are subject to dealing with this from km zero in the real world – there is a big gap of actual performance testing and data here.

Friction Facts did do a simulated longevity test across 8 lubricants representing main lubricant types (PFFE, wax, wax based, ceramic etc..). Lubricants were tested at the start, run for an hour dripping on water and sand, and tested again at the end. Some lubricants had very little shift in friction, some increased notably, and one which tested well when clean increased by 3.8w. That's in one hour.

So how a lubricant performs on a clean chain in a lab is no indication as to how the lubricant will perform once you start riding it.

How well a lubricant does or does not handle contamination depends on many, many factors. What is the actual lubrication type? What is the carrier fluid? What is the ratio of lubricant to carrier fluid? Is your lubricant actually capable of achieving the big claims it is making regarding forming protective membranes, preventing metal to metal contact or contamination to metal contact from wearing your chain metal? Does it really clean as it lubes?



Testing lubricants in a controlled longevity test is the key piece of the picture. It is all well and good to have a lube that tests very low friction on a clean chain, but if it has doubled that friction performance in few hundred km of riding then this is rather important to know. If a lubricant is fine for a 90 minute or 4 hour test but becomes very poor over thousands of km's without frequent full solvent cleaning intervention to reset contamination – that is important to know – a large percentage of cyclists just keep dripping more lube on with little to no proper chain cleaning maintenance.

The main state of play at the moment is there is either no known or accessible testing data provided by a manufacturer, or if there is data there is no detail available on the testing protocol. We also have a rather fun situation at the moment where two major players in the industry – Ceramic Speed and Muc Off – both with a lot of very fancy testing equipment – are providing test results completely at odds with each other. One of them is incorrect. Both claim to have developed the fastest lubes and chains. Any reader who has gone through the pages and pages of info from both sites would be left quite confused and with no way of determining who is right and who is wrong (at the time of writing I am trying to clarify the testing and results from both parties).

There are also times when a lubricant may perform well if a different lubrication protocol is followed vs manufacturer instructions. Sometimes the lubricant itself may be quite good, and would perform well if the amount / re lube frequency was adjusted – however it is let down by overstated marketing claims of extreme longevity performance, or the very low amount that should be added so the purchaser can expect a vast amount of km from a single small bottle etc. There are times when sales and marketing undermine what would have been an overall fine performing lubricant if a more logical approach for that type of lube was followed.

Very little proper longevity testing has been done. Simulated lab tests have typically been between 1 hour and 4 hours long, and other longevity testing has typically been done via real world riding as who is going to run equipment for thousands upon thousands of km's per test. However real world riding is unfortunately a very inaccurate way to conduct longevity testing as there are just too many variables in the key aspects that affect chain wear. Just going out riding and training subjects chains to different loads for different times, and contamination levels that are at both varying rates and introduced at varying times in the chains lifespan.

If in my testing I subjected the lubricants on test to different loads for different times and introduced different levels of contamination at different times in the chains lifespan – I don't expect anyone would place much stock in the testing results. No proper testing process I can think of would accept such variability in the key aspects of the testing and expect anyone to accept the results. Yet that is what we have with longevity testing completed via real world riding.

Also, as the testing relies on the correlation between chain wear rates from abrasive friction, very accurate measuring of net chain wear is a mission critical component. However any other longevity tests I have seen using this correlation have simply used an analogue checker unable to deliver precise wear measures. And dismayingly chain preparation can also be off the mark – with chains prepped simply by wiping the outside – leaving factory lube inside to which the lube on test is added. Not good. Added on top of the variables in load / time and contamination – you can get an idea as to how accurate some testing results may be.

At ZFC we want to ensure we stock the genuine best in class products & chain lubes to cover your type of riding and racing – be it the best for a prologue TT, a 24hr enduro, a full mudder cx, your daily commute, and every range in between. We want to have a selection of the best products depending on your level of maintenance comfort. We want to be able to demonstrate accurately the total running costs of one lubricant vs another taking into account the cost of the lubricant, usage rate and parts wear rate. We want customers to understand more about why their chains typically contribute more friction to their drivetrain than all of their bearings combined, and just how many watts (and \$\$) can be easily saved with the right lubricant. We want to know what a lubricants limitations are – what performs great when dry but atrocious when wet etc. And lastly we want to help consumers understand what is happening inside their chain and just how difficult some of the manufacturers claims are to actually execute in real life.

So for the worlds first proper longevity testing – ZFC have kept things simple equipment wise but extremely robust in process. We do not have microprocessor controlled instruments accurate to 0.02w worth tens of thousands of \$, what we do have is equipment that can be afforded to be run for thousands of km's and up to around 200 hours per test. Due to the correlation between friction and chain wear, ascertaining a lubricants performance via running chain through an actual bicycle drivetrain whilst alternating through specific clean and contamination

blocks delivers a lubricant performance breakdown to a level that has not remotely been provided previously. With all the fancy equipment of the big manufacturers you get a start friction figure and an end of test friction figure after usually somewhere between 90 minutes and 4hrs of testing. Whereas ZFC testing can assess the strengths and limitations of a lubricant through each specific clean or contamination run block and provide a full breakdown of a lubricants performance across each, as well as assessing claims vs reality – I,e ability to clean whilst lubricate etc. No other testing to date comes close to providing such a complete picture of a lubricants performance.

## **The Holy Grail Lube**

Lubes are big business – every cyclist needs one – and they are all vying for your \$. Some lubes are excellent, some are fine, some are rubbish – and it is simply impossible to tell what is what based on drip lubes type (ptfe, ceramic, wax based, nano based, dry, wet, oil etc), manufacturer claims or price.

But choosing the right lube for the right purpose not only gives you back the easiest free watts available – it also saves you lots of \$ in drivetrain wear – especially so if you run group sets at the top of each brands hierarchy. It is like double free speed!

The holy grail is to find a drip lube that matches the performance of immersive waxing in the convenience of a drip lube. Many that have purchased Friction Facts testing have mistaken the performance results of the top performing drip lubes. They will think ah look at that – almost as fast as Molten Speed Wax but all I have to do is drip it on! But the reality is – (as far as we know at time of writing), is that all drip lubes start gathering contamination from km zero. You can ride 100km and your drip lube will be black. You can ride 50km on your indoor trainer and your drip lube will be black. You didn't put a black drip lube on – the fact it goes black so quickly is a hint as to what is happening even just from airborne dust.

So drip lubes that test close to waxing performance on a perfectly clean chain in a lab will be unlikely to test near that friction level after 300km of riding. It will certainly not be remotely near that friction level after 3000km *(In FF simulated longevity testing –some drip lubes increased by up to 3.8w friction in 1 hour!)*.

Also – in the FF testing the lubricants were applied ultrasonically, with chains fully immersed in the lubricant, at a nice warm 38dg Celsius. This is not representative of how most cyclists apply their lubricants at home. This method ensures complete lubrication of all internal parts of the chain from the first articulation. However as we have seen in our testing - especially with higher viscosity lubricants – it can take some time for them to properly penetrate through to the pin leading to poor performance for the first 1000km or so , after which time there may be good penetration but there may also now be a reasonable amount of contamination gathered slowing things down.

All up – there are numerous aspects that impact the real world friction result a lube delivers vs the FF lab test results.

To remain anywhere near the friction level tested in the lab generally requires chain to be frequently removed and given many agitated solvent baths to reset contamination levels as best as possible back to near zero, and depending on the viscosity of the lubricant – a fairly involved process may be required to ensure proper lubrication of the pin and inside of inner plate shoulders (*refer lubrication gap section*). You also need to clean all the black mess off your chain rings, cassette and jockey wheels.

This is quite time consuming, costly, and you end up with a lot of solvent to dispose of somehow. But to date – we just have not seen evidence that a liquid lubricant can remain near its lab *performance (although we have very high hopes for a couple of lubes coming up on test – whereby this section will be amended)*.

All liquid lubes quickly become contaminated, and many manufacturers claims re abilities to **“clean as it lubes”** and **“form protective membranes”** is not strong past a certain number of km’s. Intervention with proper cleaning is usually necessary to reset the contamination in

the chain, and a protective film can only protect chain metal for so long against contamination particles abrading against it under high pressure. In a part performing around 20,000 articulations a minute on the large chain ring, it doesn't take too long until the sheer number of articulations hits millions upon millions. A film / membrane can only withstand a finite amount of abrasion before it is worn through and wear of hardened steel parts of chain commences. In a part working so hard, it only takes a little bit of contamination to have big impact on the level of friction losses and wear in the chain.

Which is why waxing is the tough benchmark to beat. Each re lube (re wax) is fully immersive, at around 90dg Celsius. All parts of the chain are fully coated a very slippery lubricating wax. The remaining old wax layer is melted out into the pot and fresh wax is flushed through so each re wax the contamination levels are reset back close to zero again. Forget protective membranes – every part of the chain inside and out is fully coated with a lubricant which sets solid - preventing metal on metal contact and wear. And with wax setting to an actual solid (almost all dry drip lubes do not actually go dry – just tacky) the rate of gathering contamination and the final amount gathered is extremely low vs drip lubes. When contamination contacts a liquid or tacky surface it sticks. With a solid wax, the vast majority literally just bounces off. And forget a relatively small amount of lubricant being left behind after a drip lubes carrier fluid evaporates– again the entire chain is coated with 100% lubricant.



So that is the challenge drip lubes have to try to match the outright fastest ever tested lubes of Molten Speed Wax & Ceramic Speed UFO wax. Being solid its friction performance barely shifts from the lab test performance for around 300km in normal road conditions ***(in fact it can often decrease by  $\frac{1}{4}$  to  $\frac{1}{2}$  a watt as the wax continues to "break in")***. For day to day riding and training - with each re wax re-setting any teeny contamination levels in the chain without any cleaning required, plus putting a refreshed solid coating on every part which prevents metal to metal contact and wear – we have three distinct factors that deliver simply astounding chain and cassette wear longevity rates. Most prospective new waxee's don't believe the wear rates quoted until they experience them first hand. (And of course being a proper solid – waxing is exceptionally clean).

There are some drip lubes that would remain close to their lab test levels for “X” km each re-lube if the chain is fully solvent cleaned between each lube, but not usually where more lube is simply dripped on time after time. I am expecting a couple of exceptions to this rule shortly but be prepared to pay BIG \$.

So is waxing simply unbeatable? Not quite. Despite the entire chain being coated in lubrication, the superfast type of wax used (highly refined paraffin blended with PTFE and Molybdenum) has a relatively short lifespan. Highly refined paraffin has a very low mineral oil content at around 0.5%. The wax is soft and will itself be abraded off the chain through use and from any contamination that does get into chain. It is not water soluble so it does not “wash” off easily, however in tough conditions the water being hosed onto a chain from the front wheel is full of grit, and so the wax itself will be abraded off simply from the countless articulations performed in the wet abrasive substance thrown onto it. Harsh conditions shorten the lifespan of all lubricants – solid wax is no different.

The advantage of the wax is that it absorbs contamination from harsh conditions at a very low rate vs liquids. Initially its very low friction performance remains pretty much unperturbed. The disadvantage is that the wax will itself be abraded off relatively quickly and once it is gone friction will increase quickly and dramatically. So if you have a long wet race or enduro etc – it may not survive to the end. Remember of course that all lubricants lifespans are shortened dramatically in harsh conditions. So whatever film or membrane or lubrication vector other lubricants have will also be abraded off much more quickly vs good conditions. The difference with drip lubes is that the liquid itself is lubricating and so as long as some liquid remains there is some level of lubrication. The downside is that the liquid will itself have grabbed and held a lot of abrasive particles, so it is part lubricant, part liquid sandpaper. It is common for a chain and cassette to be pretty much destroyed at the end of a 24hr mtb race – whereas in normal riding training and re lubing one does not go through a chain and cassette every 24hrs.

So it can be a bit of a paradox – to start with waxing will be super low friction and resist increasing in friction for an impressive period, but then once gone there will be a large jump in friction. Will this work out better overall than a lubricant that will start higher friction, increase in friction notably and quickly as it becomes a bit of a liquid sandpaper – but then hold at that level for many hours? Is it better to be at 4w friction for “X” time but finish the latter part of race at 15 to 20w, or start at 5 to 8w, very quickly get to 10 to 12w – but remain in that ballpark

for many hours? The length of the event and conditions will determine whether it is best to go flag to flag with wax, start with wax and re lube, or go flag to flag with an extreme conditions lube if stopping to re lube is not preferable.

So there will be events where a long lasting drip lube may be preferable to waxing overall due to its longevity – But what drip lubes perform best here? Can't wait to find them.

And of course waxing – despite being a smart choice for many who initially didn't know there was another option to drip lubes – will never be for everyone. For a lot of people there is a mental block re removing chain to put in pot of melted wax. Removing chain to solvent clean seems perfectly normal however, and so mass market will likely always want something to drip on and either periodically clean, or never clean – and look for what delivers the best results for their level of application and maintenance comfort.

Lastly - since the FF testing there have been some exciting new lubricants out with some exciting new tech and making some very big claims indeed. Some honestly I can say already will likely be hogwash, but excitingly some others look to be very very good. I can't wait to test and see. I hope to find some bona fide great product options to our stock line up.

And so here we are.... 😊

Below is all optional reading – the more you read – the more you will understand about your chain, lube choices, manufacturer claims vs reality, and how to easily save some great watts AND \$\$ at the same time - especially for those who race, do sportif's / gran fondo's. There will also be some links to a couple of the best articles one should read to fully understand about chain friction and this testing.

So let's kick off - Enjoy!



## About chain wear in general

Chain wear is usually measured via chain elongation or “stretch”. The plates of the chain are not stretched longer, however wear of the chains parts – mostly the pins being worn thinner and the bore of the inner plate links being worn larger, means that each link can be pulled a little longer than when it is new.

Measuring chain wear accurately is surprisingly complicated and often not correctly or accurately. The generally accepted “most accurate” is to hang the chain and measure total elongation vs new – and this will give an accurate chain elongation wear measure. The problem is that rather annoyingly chains wear at different rates in different sections – and the difference from one section to another can be quite large indeed. An elongation measure taken across the entire chain will not this up – and if one section of chain is notably more worn than the average wear the elongation measure shows – the section with larger elongation is still going to cause accelerated wear of cassette and chain ring teeth. So replacing one chain at 0.75% wear one time may have a rider fine to run a new chain on same cassette, and another time the cassette may be badly worn and not accept a new chain despite replacing chain at same wear measure.

Measuring multiple sections from centre of pin to pin with a digital caliper is a better way to measure chain – so long as one is very accurate with lining up two centres of pins – tiny fractions of a mm = a large difference in wear rate calculated – and multiple sections of chain need to be checked for an average result, and even tension in the chain needs to be applied. Unfortunately some lubricants that are fairly viscous and / or if a lot of contamination is built up in the chain – this can easily prevent pins from being pulled to their true wear mark as gritty lubricant is filling the gap. Under rider load however the pin will be pulled through this – and so it can be easy with some lubricants to give falsely very low wear rates using pin to pin measuring – and again to be accurate one needs laser eyes and a steady hand to get multiple true centre to centre of pin measures across a good span of say 10 links to calculate wear.

So making it easier – sort of – are a whole array of chain wear checkers, some are drop in, some are slide in, some try to isolate roller wear from the equation. If you read some forums you will often find engineers of some degree or another denouncing chain wear checkers as a

huge waste of money, flawed etc – just use a ruler / digital calliper. And yes the issue with most chain wear checkers is that at the two insertion points the checker will also be measuring wear of the inside of the roller bore and wear of the outside of the inner plate shoulders that articulate inside the roller. These two areas of wear have no impact on chain “stretch” or elongation. Some checkers are designed to isolate this wear from its measures.

So, yes – many chain wear checkers are going to measure two types of wear at two points on the chain, and just elongation across the rest of the span it is checking. One can only hope that the manufacturer of the checker took this into account when calibrating their tool. What these checkers do provide however is a quick and easy way to check multiple spans of the chain, and if used correctly can be a cyclist's best friend re saving a fortune on not having to replace cassettes every time they replace their chain.

Where these fall down is often in two parts;

- 1) Most are too generous re wear allowance – by 1.0 the chain is ruined and so will have already ruined your cassette and had a good crack at your chain rings. Even by 0.75 measure it is touch and go, and you can be almost guaranteed that if one section of chain measures 0.75, another section will be around 0.9 – and so can still easily result in goodbye cassette.
- 2) They are very susceptible to the amount of user pressure applied, and need a consistent tension in the chain. If one checks the chain above the chain stay with little to no tension in chain, or check chain beneath chain stay in “X” gear which will put “X” amount of tension in bottom span of chain from derailleur pulley can easily get highly varying results. With chain wear measuring we are measuring small fractions of a mm, so differences in user pressure and chain tension can easily have one person check a chain and say it is almost new, and another person check same span and say it needs replacing. And again some lubes will mask the true elongation wear unless a lot of tension is put into section of chain prior to measuring, whereas others require very little tension to reveal an accurate elongation wear measure. For my two cents worth, the Park Tool cc3.2 is the best analogue checker, it is a drop in checker with a 0.5 wear measure mark which is perfect – used correctly I have never ever had a time where a cassette does not accept a new chain when the existing chain is replaced at 0.5 wear mark. A conservative chain wear checker is not a conspiracy theory tool to have you buying chains more often than you need – it is your best friend to save you a fortune over time in cassette and chain ring wear. (And worn chains perform like crap – a 1% worn chain will be around 2w higher friction than same chain new – even when perfectly cleaned and re lubed).

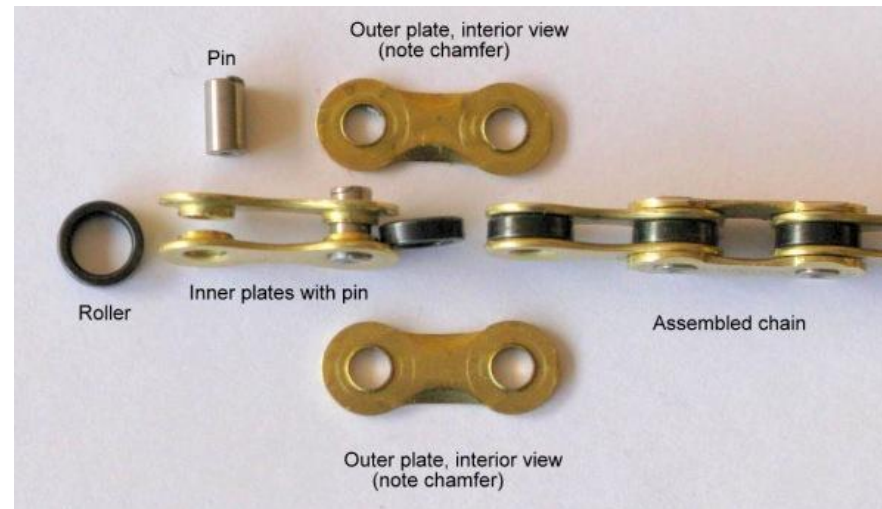
It is also worth noting that the wearing of the inside of the rollers and the outside of inner plate shoulders is still actual wear and it still contributes to a chains performance and damage to cassettes and chain rings. Some lubricants can be quite good at preventing contamination getting through tiny gap to the pins and so have a relatively good rate of elongation wear, but have gritty liquid sandpaper running inside rollers. I have seen many chains where elongation wear was not terrible but rollers were flopping about all over the place and could be shifted millimetres to the left or right. So isolating chain elongation wear only is not the be all and end all it is cracked up to be. Ideally there would be a tool that accurately measured elongation AND roller wear easily across a span of links vs trying to isolate wear measuring of elongation only – but this tool hasn't been invented yet.

And very importantly, - chain wear and friction is not a linear increase over time. Good quality chains come with a low friction coating, and the better ones have something like a Zinc Alloy or Nickel or Ti Nitride plating on inner and outer plates, and even better chains have specific very hard coatings on pins and rollers such as chromium carbide. These coatings and platings play a big part in a chains friction performance and durability – but they are also the first to be compromised from abrasive wear. With many drip lubes this can occur frighteningly quickly. It is part of why world tour teams tend to replace their chains every 500 to 1000km. As the coatings / platings become compromised, friction and wear rates increase. Also, without regular proper cleaning for most drip lubes the ratio of contamination vs lubricant inside the chain will generally continue to get worse and worse. As such a chain subjected to the exact same level of load and conditions will usually exhibit a higher friction and wear rate between say 2000 to 3000km than it would have from 0 to 1000km. Most times there is the double whammy of lubricant is now more contaminated, and protective coatings / platings no longer exist *(take for example the Rock n roll gold test – wear rate for 0 to 1000km was 8.9%. From 2000 to 3000km which was again a clean block with no added contamination it was 20%)*.

This often catches cyclists out. A cyclist may check wear at 2000km and be impressed with low rate of wear. Check again at 4000km and find it has ripped past the 0.75 mark and now they need a new cassette as well as the chain. Most annoying.

It is also a key reason why we recommend cyclists who race or compete in sportif's / gran fondo's etc have a dedicated race chain and training chain. It is the easiest and cheapest watts savings you can get. You are always going to need another chain – so simply pre buying your next

chain has a zero net cost. When training chain reaches 0.5 wear replacement mark – race chain becomes training chain, buy another chain to be your race chain.



*(Pic sourced from slowtwitch)*

Did you know? - When a chain's roller contacts chain ring / cassette teeth etc, the roller stops moving and the inner link plates articulate inside the roller. The pin is also riveted in place to the outer plates so it doesn't move either – the inner link plates articulate around the pin. Therefore as the link articulates, the inner plates are the only rotating parts; however there are multiple friction and wear interfaces;

- The inner plates will articulate around the pin on the inside bore of plate shoulders (those flanges you can see that the roller sits on) under full pedalling load.
- The outside of the plate shoulders articulate inside the roller under full pedalling load.

- The inner plate slides against the outer plate on both sides of the link – the pressure under which it is doing this is dependant on both rider load + chain line angle.
- The inside of the inner plate sides slide against the sides of the roller – again the pressure under which it is doing so dependant on both rider load + chain line angle.
- Chain wear occurs from the pin being worn thinner, the inside bore of the inner plate shoulders being worn larger, the outside of the plate shoulders being worn thinner from articulating against the roller, and subsequently the bore of the roller is being worn larger. As these parts wear down, each link can be pulled slightly longer than when it was new, and rollers can start to flop around on inner link shoulders.
- The wear of the inner plate against outer plate and sides of the inner plate against side of rollers does contribute to friction, but does not contribute to “chain stretch”. The loads here are much lower than the full rider load which causes chain elongation wear. Over time – especially for those who with large chain angles a lot – a condition known as “chain slap” may develop where the chain becomes a bit too laterally flexible resulting in poor shifting performance. Derailleur chains do need to be laterally flexible, but there is a sweet spot.

Up to 0.5mm across 8 links is very close to 0.5% wear on a 108 link chain, and this is the best limit to use as a guide to replace chain as it is getting to the maximum tolerance of the spacing of your cassette & chain ring teeth. Stay within tolerance and the rollers will slot neatly into the teeth without abrading their way down the face of each tooth. Let chains get to 0.75 and the rollers are starting to hit the tips of each tooth first before being forced to sliding down the face. By 1.0 – things are getting pretty bad – the more chain stretch the more your chain is rapidly eating all your teeth thinner.

And not surprisingly, having your chain eating through the metal teeth on your cassette and chain rings is not exactly low friction either. It should not come as a shock that abrading through metal whilst pedalling along eats up watts as well as \$ from your bank account.

So, replace chains at 0.5, and save a bunch of watts and cash, and have a beautiful running drive train. It is also a lot safer. A worn chain is much more likely to fail – with very thin chains and greater chain line angles of 10, 11 and 12 speed drive trains, running clapped out chains greatly increases chance of failure. This can have you over the handlebars in a sprint and bringing down a pack, or if your chain goes into back wheel it can cause a spectacular amount of damage to bike and frame as it rips your rear derailleur from frame and into back wheel etc. In summary – your chain is your hardest working mechanical part, and running completely exposed dust and the elements. This makes it a highly consumable part – stay on top of chain wear for watts, \$\$, the silky smooth pleasure of not riding a clapped out drivetrain, and safety.



**(New vs worn chain ring teeth. The exact same thing happens with your cassette teeth only much faster. Abrading away metal is not low friction. Replace chains at 0.5 and your chain rings will last almost indefinitely, and you will always get 2, often 3 chains per cassette. Let run too long and it is almost always new cassette time when it's new chain time, and can also easily lead to new chain ring time too. This is a very expensive way to run your bike vs simply replacing chain when it should be replaced.**

## **The lubrication GAP!!**

There are three critical area's to ensure lubrication for the chain as it articulates under load. The two most important areas are;

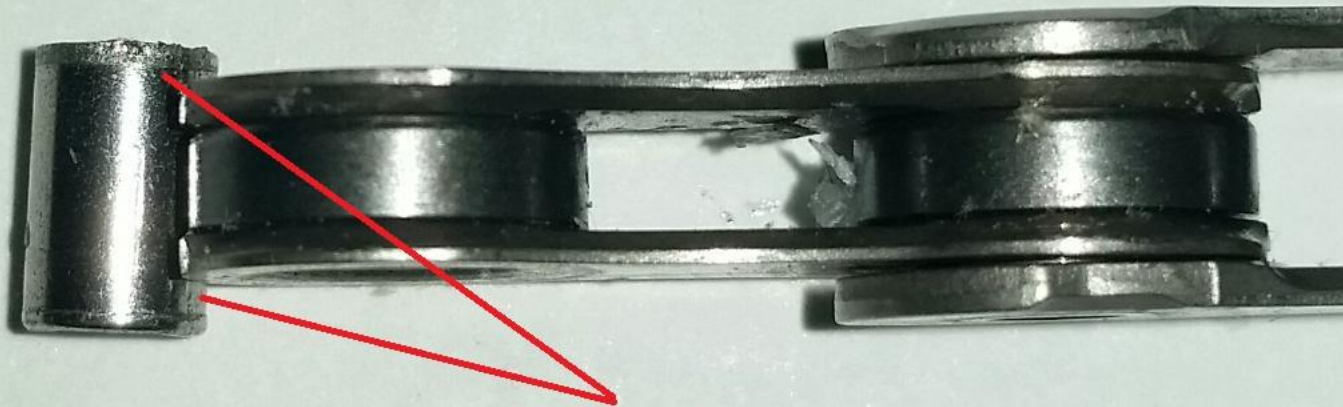
- 1) Between the roller and the outside of the inner plate shoulders as they will rotating inside the roller under full rider load.
- 2) Between the pin and the inside of the inner plate shoulders. It is wear of the pin and inside bore of the inner plate shoulders that is measured with chain elongation wear measuring. These two interfaces are also articulating under full rider load.

The last place that needs to be lubricated is between the inner and outer plates on both sides of the link as they will slide against each other as the link articulates, however when chain line is straight there is very little load here – it increases as chain line angles increase (and similarly there is friction between side of the roller and side of the inner plate which will come into play more at greater chain line angles).

In general lubricants will not have too much trouble penetrating and lubricating between roller and outside of inner plate shoulders or between the inner and outer plates interface, side of rollers and inner plate interface.

The trickiest part is to get lubrication into the other extremely important area under high pressure friction load – the pin and inside of the inner plate shoulders. Access to get into here is very limited now that chains have become super narrow as demonstrated by image below.

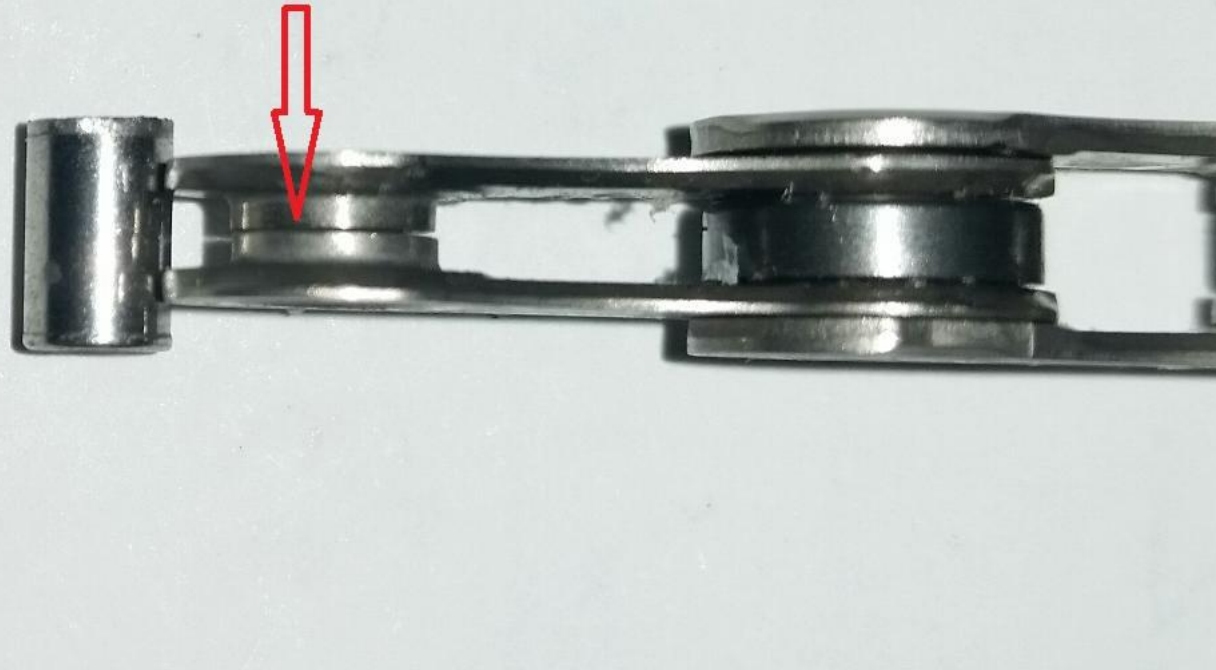
Pin is riveted to outer plates & does not move. Inner plate articulates around pin. When roller contacts teeth roller stops, and so inner plate also articulates inside roller.



Note amount of pin width that requires lubrication - inner plate shoulders articulate around this area under full rider load.



Note lubrication gap through which lubricant must penetrate & disseminate across pin width. Any contamination gathered by lubricant also needs to get back out of this gap, and back out past roller to outside of the chain.... Tricky



Not all chains are the same here – some chains will have thinner plate shoulders and a larger lubrication gap, some will have wider plate shoulders and a very narrow lubrication gap. Thin lubricants will generally not have too much issue penetrating across pin quite quickly, however more heavily viscous lubricants most definitely can.

Note chamfer on outer plate. This prevents lubrication from also being able to access pin via gap between inner & outer plates, leaving the small gap underneath roller as the only lubrication gap access to pin.



As we discovered with testing for some of the top wax emulsion drip lubes with Squirt and Smoove – the importance of this lubrication gap was demonstrated very well with initial block 1 wear rates vastly higher than expected, and then showing an improvement trend - in Smooves case the improvement as km's went on was very stark indeed – showing only 2% wear from 2000 to 3000km block vs a 19.1% wear rate from 0 to 1000km. This is the opposite of what normally occurs with drip lubes without regular cleaning maintenance whereby as the contamination to lubricant ratio continues to increase – so does wear rates so the block 3 wear for most drip lubes will be much higher than block 1 because more contamination is running in the chain and any chain platings / coatings have been compromised.

However with certain lubes such as viscous wax emulsion lubes – the opposite effect was seen as over time and many re lubes more of the viscous wax was able to penetrate to through this lubrication gap to get to where it is needed build up layers of lubricating wax.

As such one will see in the reviews for Squirt and Smoove a recommended technique for initial lubrications after cleaning chain of factory grease that is **much** more involved than the manufacturer instructions which yielded very high block 1 wear rates due to lack of lubricant penetration through this gap.

This gap is also important to take into account as we move to covering other common manufacturing claims such as forming clean protective membrane on chain to prevent metal on metal / contamination on metal contact, as well as cleaning as it lubes by shifting contamination to the outside of the chain leaving just clean lube inside the chain. Both are a tricky promise to deliver on.

So let us ponder this challenge a little bit. Take your current chain and run your hand or cloth along it. You get a lot of black contaminated lube on your hand / cloth. If you were to completely clean the outside of the chain so that it looked brand new, and then take chain off and put in a container of solvent and give it a shake – the solvent would instantly turn black from the black contaminated lube running inside the chain that is now flushed out.

So when you add fresh lube, this liquid is running through all this black contaminated lube on its way to the inner workings of your chain. And if most manufacturer claims are to be believed – it is apparently doing so without getting contaminated itself, penetrates through this very narrow channel to lubricate the pin without bringing any contamination in with it, shift any contamination that is in there back out of this very narrow channel, and then shifting it to the outside of the chain. And after having achieved those feats it then leaves a nice clean film / membrane of lubricant behind protecting chain metal from contamination abrading against it causing wear / prevent metal on metal contact.

Tall orders. All of them.

The level at which a lubricant does or does not achieve these claims has a very large impact on chain friction and wear once the lubricant leaves the lab and has to contend with contamination. Different lubricants grab and hold contamination at different rates. Different lubes penetrate the lubrication gap to pin without difficulty or with great difficulty. They have differing abilities to shift contamination from inside chain back outside again. They form differing strengths of any protective films / membranes. The combination of all these factors and many more will determine a lube's day to day performance in the real world, how close it remains to its lab performance and for how long, how much maintenance / intervention is required to keep it performing well, and what conditions it can or cannot handle.

**So far our proper longevity testing has delivered some important learnings in this area vs short lab testing.**

- 1) Highly viscous lubricants such as wax emulsion lubes (Squirt / Smoove) when applying to a chain stripped clean of factory grease, I would recommend re lubing very frequently early – after every ride – for at least the first 5 rides to ensure sufficient penetration through the very narrow lubrication gap to the pin and for it to begin to build up lubrication on the pin. Try to ensure applying whilst lube is warm and chain warm (i.e indoors vs outdoors in winter). Don't worry about that you will build up tacky stuff on the outside of chain and drive train more quickly - you can clean the outside of the drivetrain as you need. After this initial lube rate you should then move to normal manufacturer recommended re lube rate – just keep ensuring lube and chain warm for application and thoroughly work in with lots of back pedalling in small cogs whilst wet after applying.

*(\*If I was preparing a chain for a big event like a 12 or 24hr mtb race or long gran fondo like 3 peaks – I would follow the detailed prep instructions as outlined in detail reviews for those lubes. One lube in particular has demonstrated it effectively “Layers”, so allowing each application to thoroughly dry after taking pains to work into chain whilst still wet, and repeating to add another “layer” – has shown to be effective with Smoove – but that is the only lube seen to date where this is the case).*

- 2) For normal / light viscosity lubes – the concern is not about penetration through this gap – but more so regarding how much abrasive contamination it brings in with it on its way through, and how does it get contamination back out through this gap and leave behind clean film / membrane only? So when prepping a chain here it is simply ensuring a proper clean first, then thorough lube whilst articulating chain around drive train, and thoroughly wiping excess. Repeatedly adding more and more lube - as recommended to ensure penetration with highly viscous lubricants - is not recommended here. Penetration is not a concern and excess lube is simply going to gather more contamination. Properly clean, thoroughly lube, wipe excess , let dry if specified – prep done.

## About Chain Break in!

There will be a surprising amount of metal particles released when you first ride a chain – left over from the manufacturing process. The factory grease is quite good at absorbing these metal particles, and also forming an initial level of smoothing / polishing the metal surfaces. There is a nice little butter zone here to set a chain up well for its future performance, a bit like a proper break in for a new engine.

Too often cyclists buy a new chain, ride the factory grease until its getting dry, then start adding drip lube. Aside from the fact that the drip lube will be highly tainted by the factory grease and unlikely to be able to perform as designed (bond to metal surface, form lubricating protective film / membrane etc), but also without proper clean post a couple of initial runs – you are going to be leaving a lot of metal particles running in your lubricant. These particles are – like your chain – made from hardened steel.

So in the same way you wouldn't tend to sprinkle hardened steel particles on you chain for fear of greatly increasing friction and wear, one should also look to remove hardened steel particles after an initial 1 to 2 hours of riding with factory grease.

Friction Facts have tested that even a rudimentary break in such as the above will reduce chain friction by around 0.5w, and this will carry forward for the chains performance once cleaned and lubed with your lube of choice. You will find that all race prepped chains have had an initial break in with factory grease prior to ultrasonic cleaning (if a company is making race chains without an initial break in, they are short cutting a very important step.

You can see from the images below the amount of metal that initially comes out, and so left in after an initial break in is likely to start causing premature wear and damage – especially to the special plating and coatings your chain main have depending on the level of quality of your chain.

- Note for waxing customers – if purchased a pre clean and waxed chain then a nice amount comes out from the many rounds of ultrasonic cleaning, and the remained will come out over time as you re-wax. This does mean it is going into your wax, but you will still have vastly less metal particles running in your chain vs those adding drip lube on to factory grease.
- There is now an option to purchase chains that have been broken in , ultrasonic cleaned and waxed, as mid price option between a clean and wax and a fully optimised race chain.
- However if you want to save your \$, you now know what to do with your new chain at home. Ride for 1-2 hours with factory grease in clean conditions – fully solvent clean with agitated solvent baths, always finish with methylated spirits to ensure no film left from degreaser or similar so that new lube has direct access to chain metal, and away you go.









## About having a dedicated race / A chain

So as discussed - your chain is a very consumable item. Sooner or later you are always going to need another chain, and for those that race or do sportif's / gran fondo's and so tend to clock up some training miles, needing a new chain is never too far away – especially if replacing at recommended 0.5 wear mark.

It doesn't cost any more to simply pre-buy your next chain and have a dedicated race chain. This chain you break in with around 100km of riding with factory lube, remove and fully solvent clean, lube as per instructions with your chosen race lube, and keep it wrapped in cloth ready for next race. Properly clean and re-lube after each event to keep it mint. Most especially so if using drip lubes - this will give you some of the cheapest and easiest watts savings you can get. Versus racing on the same chain you use in training that will be contaminated, compromised coatings / platings, some level of wear – you can expect to save at least around 3w @ 250w load, possibly quite a lot more, and with this figure nearly doubling by 500w, nearly triple at 750w (power climbs, attacks etc) as chain friction increases at an almost linear rate to rider load.

When your training chain reaches 0.5 wear, your race chain moves across to become your new training chain, get new chain to become dedicated race chain – break in, clean and lube with your chosen race lube. This method is simply one of the smartest, easiest and cheapest ways to save a bunch more watts than you will with very expensive bearing upgrades – and it will save you money on drive train parts by having them last a lot longer. Double free watts!

There are also numerous options to buy a pre prepped racing chain to skip the above hoohaa, and then all you need to do is the keeping it mint part.

*\*Note - New chains will decrease in friction by around 0.5 to 1w after being "Broken in". Break in your new race chain by riding for around 100km in clean conditions and then properly clean – ensuring flush out ALL the contamination you can. If it is not properly cleaned – friction losses from contamination will undo the friction gains from break in.*

# Ok – onto manufacturers claims!

## **Forms a protective film / membrane**

This is the big one. A lubricants ability or lack thereof to form a film / membrane to protect the chain metal from either metal to metal contact under rider load, or abrasive contact from contamination on chain metal under load - will have a huge impact on chain lifespan and real world friction performance. This is a big part of what can separate those with a good lab performance but poor performance outside of clean chain clean lab testing and those that remain close to lab test results for an impressive period of time.

Almost all lubricants claim to form a high strength film / membrane that protects chain from metal to metal contact & contamination to metal contact – both of which cause high friction wear to a chains hardened steel parts. And there is huge variance in the industry regarding which lubricants do this well as per claims and which do not.

The challenge of achieving this well with a drip lube is substantial. Initially – assuming one has properly cleaned chain and applied lube as per instructions – it is likely that if a manufacturer is claiming this property for their lubricant – it is doing so. But how well...

The variances come into play with;

- A) How strong is this protective film / membrane – can it prevent metal to metal contact / contamination to metal contact under high power rider load?
- B) How long can this protective film / membrane last against the abrasive assault from contamination?
- C) Part B may be determined by how much and how quickly the lubricant gathers contamination, as this will determine the level of abrasive assault being mounted against the film / membrane.

There can tend to be two stereotypical scenario's;

- 1) A light bodied drip lube which may go semi dry and have a lower amount of contamination gathered to abrade against film / membrane. However the film / membrane formed may not be strong enough to prevent metal to metal contact under rider load, and it may be worn through quite quickly even from the relatively small amount of abrasive contamination gathered.
- 2) Or it may be a heavier / wet lube that may form a stronger film / membrane – however wetter lubes also tend to gather more contamination more quickly. A stronger film / membrane will resist metal to metal or contamination on metal contact at higher loads, however if it is under assault from a veritable battalion of gathered contamination – it may still be abraded away in short order.

The best possible scenario is a lubricant that has a very strong layer of protection against metal to metal & contamination to metal contact under load, and that also gathers a very low amount of contamination very slowly. Unsurprisingly immersive waxing is extremely hard to beat here – every surface of the chain metal is protected with a completely solid layer of lubricant vs the very thin film / membrane from a liquid. And being completely dry and solid it gathers extremely little contamination – most literally just bounces off. Whereas with the exception of the Ceramic Speed UFO drip lubes, other “dry” lubes do not go truly dry – either less wet, or very tacky. The abrasive assault against the wax layer is typically very low compared to what the liquid film / membranes need to contend with.

The other extremely important aspect to consider is what is happening when you are re-applying your drip lube. Few riders are going to fully clean their chain after every ride, or even perform frequent proper maintenance with a full flush clean every 1000 to 1500km.

So the drip lube is added to a chain full of black contaminated lube, upon which the lubricant needs to pass through all this without becoming contaminated itself and form a new clean protective membrane between the contamination and the chain metal. Honestly that is some feat. The fact that the majority of chains on drip lubes will hit 0.5 wear mark within 3000 to 6000km speaks to the general level of success here I think – the hardened steel parts of your chain are still being abraded through – if a membrane was preventing metal to metal contact or abrasive particles contacting metal and the links were articulating just on a nice clean membrane – the links would not wear.

At the time of writing – I find this claim to be a stretch for most lubricants. I think many form a decent film / membrane when applied to a clean chain and that this membrane will reduce friction and wear for a while. However just adding more lube on and expecting a nice new clean film to form despite chain being contaminated takes a bit of faith, and I expect any new film / membrane to hold up for lesser and lesser time as contamination assault against it continues to build.

This is demonstrated well in our testing by much higher wear rates in subsequent clean blocks during the test vs the lubricants clean block 1 wear rate (in most cases – but not all 😊). The usual continual acceleration of wear is an indication re how well this claim is being executed.

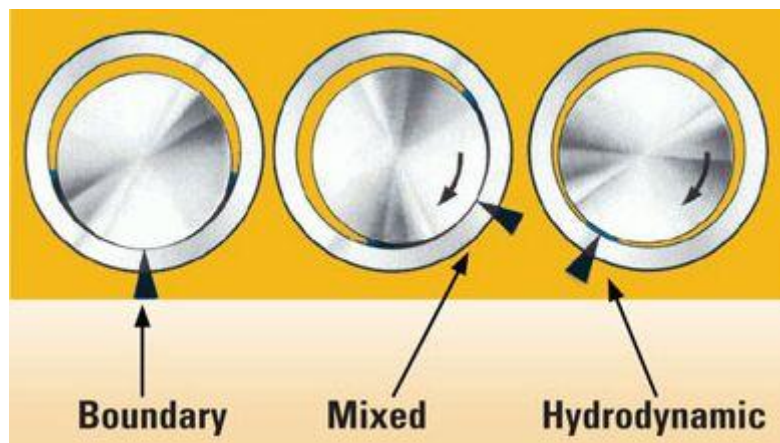
So – in summary – almost all lubes will claim to do the above – but in practice how well they actually achieve this aspect will have a huge bearing on their real world friction and wear performance – and the level to which the lubricant performs here is be uncovered in our longevity testing, and not usually revealed too well in lab testing.

The below is from Bike Mechanic website (makers of bike milk / bike mix / bike syrup) and may help explain what we are talking about re lubricant preventing metal on metal contact. Many thanks to Owen for sharing some great extra knowledge that assisted me in solving the mysterious initial wear rates for Squirt / Smoove – very few people have Owens level of knowledge on chains and lubricants!

#### MECHANICS OF CHAIN LUBRICATION & EXTREME PRESSURE ADDITIVES

The extreme pressure additives in BIKE SYRUP are designed to coat and bond to the metal surface. This prevents metal-metal contact and reduces noise. It is the fundamental reason the chain runs so quietly.

Lubricant mode of action can be simplified into 2 types: boundary and hydrodynamic. Hydrodynamic lubrication requires a film of liquid to remain in between the two surfaces. Under high pressure loads such as those experienced in between a chain pin and the bushing the liquid lubricant required for hydrodynamic lubrication is squeezed out of the space between the two surfaces and boundary lubrication is required for effective protection.



The best boundary lubricants are long chain molecules with an active end group. The active end group attaches itself to the metal surface and gradually builds up a surface layer. The long chains form a layer of lubricant which separates the metal surfaces and there is no direct contact of the sliding parts. This situation is required for many extreme pressure applications to prevent severe wear or high coefficients of friction and seizure

## **Drip lube “Cleans as it Lubes” claims.**

This is the next big one. Again just about all lubricants claim to do this - and there are various methods via which lubricants claim they achieve this feat.

Firstly let us look at the manufacturer claim for one of the lubes tested so far – Rock n roll gold;

*“The formulation goes deep down into the chain and traps any dirt. Then, with the energy of the chain freewheeling backwards, the dirt and grit floats to the surface so you can wipe it all off, leaving a new and clean application of lube inside the chain, where it’s needed. The lube down inside the chain creates a protective membrane to seal out dirt and moisture from the moving parts of the chain. As well as holding in place the best lube on the planet, for longer chain life, super smooth shifting and pedalling”*

And yet during the test, the wear rate in block 3 which had no added contamination was over double the wear rate for block 1 which started on a clean chain. When the chain was properly cleaned after main test for the single application longevity test, the wear rate for the first 250km was reset be extremely similar again to the wear rate recorded in clean Block 1. In short – properly cleaning the chain removed a heck of a lot of contamination that the re lubing didn’t. Rock n Gold did perform some level of cleaning as the wear rate reduced by nearly a third on block 2 wear rate which had added contamination – so their claims are not all hyperbole – but it is up to you as the consumer to decide if “less dirty” can be classed as “clean”, and if the level of cleanliness achieved matched your expectations after having read what the manufacturer has advised it would do.

So drizzling on a lot of new lube and wiping away excess may perform a level of cleaning. But it may be quite small.

When I properly clean a customer’s chain it takes around 10 x 200ml agitated solvent baths to flush chain clean. The first bath goes instantly black. The second bath goes instantly black. And again, and again. After about 1 litre it is now starting to turn grey, then lighter grey, until finally around 2 litres later the mineral turps comes out similarly clean vs how it went in. The amount of particulate contamination captured when I pour the turps through paper towel as I go is huge. You can obviously easily test this yourself with your current chain at home! So – just how much contamination can really be flushed out with about 10ml of a lubricant across 108 links is worth pondering. I find these claims



akin to the following analogy - Think of a sink full of dirty water from washing a pile of greasy dirty dishes. Imagine turning the tap on for 1 second whilst simultaneously pulling the plug for 1 second. Is the water in your sink now clean?



(Solvent clean of Rock n Roll gold after 3540km. 2 litres of mineral turps before it was coming out similarly clear to when it went in. So, was RNR gold cleaning as it lubed? You can see what is running inside the chain along with any new lubricant that is added, and you can imagine the task for the lubricant to form a new clean film between contamination in the chain and the chain metal. And if it does achieve that feat, how long can said film last against such an abrasive assault? It is also worth noting Rock n Roll gold is one of the better performing lubes, what is happening with lubes that achieve claims to a lesser degree?

Use of sandy loam as our contamination also really highlighted what happens when more lube is applied / chain wiped during re lube. Sandy loam will crunch away very audibly when it penetrates inside the chain. After running for a while, this crunching / grinding sound stops as now the worst of it has now either been ground to dust or it has been worked to the outside of the chain. However when lubricant is added again at next re-lube interval – the crunching and grinding sound immediately recommences. This proved a long held concern - drip lubes are applied on the outside and work their way in, as such they risk bringing contamination sitting on the outside of the chain back in with it. If one was to carefully apply a small drop directly onto roller – this seems to minimise this occurring, however lubes that want you to drizzle on whilst back pedalling and then wipe chain clean – there is a big pick up in crunching going on inside chain after each re-lube. So during re lubes – yes fresh lube is being added, and yes to a very very small degree the total level of contamination in the chain may be diluted. But things may also get worse for a while before they get better where it really counts – inside the chain. The outside of your chain looking cleaner counts for very little. It is hard to imagine a liquid applied to a contaminated chain won't itself become immediately contaminated on its way through penetrating from outside in. At the time of writing I have not seen a drip lube that is “cleaning as it lubes” to any feasible definition of “clean”. It may make chain look clean on the outside for a while, but pop chain off and give it some solvent baths and you will see what is running as lubricant inside the chain where all the action is happening.

- Lubes that contain solvents – these may help in a couple of ways. If you haven't cleaned your chains factory grease / oil (which tend to grab a lot of contamination), these solvents can help remove factory grease / mineral oils so that more and more you are left with the lubrication you have purchased being what is lubricating your chain. But these solvents are not acid – they are not going to dissolve dust and grit. These lubes can gather less contamination overall and at a slower rate than a mineral oil / factory grease - but the solvents themselves won't “clean” your chain of dust and grit.
- Note - for the vast majority of lubes - removing chain and properly cleaning will deliver a significant reduction in friction and wear, and this is highly recommended to do prior to races / events if you use the same chain for racing as you do in training. However – there are some lubes which focus on building up a lubricating layer inside chain and so do not wish the user to fully clean chain as that will remove lubricating layers built up. The longevity testing has proven this to be correct for these lubes, however I find it would be a big call to say that a very clean chain with a fast lubricant is not going to outperform a chain that has simply been re lubed for “X” hundreds or thousands of km's and will have gathered an amount of contamination. So for those running lubes that require time and layers to build up, I would still highly recommend fully cleaning as contamination always ruins a low friction party, and then follow my more

involved recommendation re building up lubrication layers in a way that keeps contamination gathered to an absolute minimum. The goal always for a race chain is a perfectly clean, perfectly lubricated chain.

- In testing an issue has been discovered with some the drip lubes that go quite dry or become like a “plastic” state. These lubes can resist gathering contamination well during normal dry riding and also in dry off road conditions. However during wet ride conditions, the water provides an easy vector into the chain, however the lube may have no mechanism to shift the contamination back out again. Some dry / wax lubes “shed” – and so use up some of themselves in an attempt to shift contamination back outside the chain – which can provide a small level of cleaning at a cost of longevity for the lube application, however some do not really shed and have simply no way of getting contamination back out. These lubes typically have a frugal application process, so there is no flushing out of contamination either. Lubes of this type can be a bit of a catch 22 as whilst they can be excellent at resisting contamination in the dry, and perform at a comparative high level during a wet ride or event, one can be left with task of fully cleaning chain after wet rides or the contamination hosed in by front wheel is simply going to stay there resulting in high friction and wear for subsequent rides post any wet ride. Compounding this is that some of these lubes can also be quite viscous and take time to properly penetrate through lubrication gap to pin again after chain has been properly cleaned – again leading to either high friction and wear rates for a while post clean, or if wish to avoid that quite a rigorous process post clean to negate this.

## **DRY LUBES**

Most manufacturers know that many customers covet a clean drivetrain with a minimum of hassle & cleaning maintenance. When it comes to dry drip lubes they are attempting to act like a solid lubricant. They are a lubricant (often a type of wax or a blend of multiple types of wax) suspended in a carrier fluid which then evaporates to varying degrees, leaving behind said lubricant. In reality this is not always executed well – very few dry lubes go actually dry – they go sort of less wet and become tacky, and some leave behind very little actual lubrication. As a grouping dry lubes often friction test poorly and can have a frighteningly short lubrication window.



(Lubricant vs carrier fluid. Imagine if you will the amount of actual lubrication left behind each re lube vs other lubricants where the majority of what is being applied is the actual lubricant. You could drizzle half the bottle on, and across 108 links the amount of lubrication per link will still be not much! The above lube tests terribly in every test it has been subjected too)

There are a couple of good exceptions to this rule though where this approach is done very well, with a large of amount of lubrication left behind after carrier fluid evaporates leading to a slower and lower rate of contamination gathering. The best have tested very well for efficiency and longevity, however as a nice paradox these most certainly do not remain clean. In fact one of them built up so much gunk during test I was no longer able to back pedal the drivetrain when reapplying lubricant – so cleaning maintenance for these lubes is high if you want a clean looking drivetrain. Done poorly – and these are often the cleanest looking ones - there can be so little lubrication left behind that quite quickly after each re lube there is simply so much metal / metal and grit / metal contact they deliver very poor friction levels and very high wear rates. And you certainly would not want to be out on a wet ride or you have about 30 minutes of lubrication, after that the water being sprayed onto your chain will be doing the majority of the lubrication! So, some may look cleaner on the outside vs a wet lube, but in a lot of cases the beauty is only skin deep – what is happening inside where it counts can be not great.

So in short - dry lubes done well can be very good, done poorly and they can be pretty shocking.

## About “metal conditioning”

There are some lubes (of which we will get around to testing hopefully) that make some other interesting claims re why their lubrication is the best. One of them is that if you were to look at the metal under high magnification you would see that the metal is not perfectly smooth but the surface is covered with fissures, and that their lube fills these fissures to leave a completely smooth surface. I have no grounds to believe their lubes are not actually doing this, or trying to do this, however I speculate that contamination is merrily scratching in new micro fissures every time the link articulates. Which is a lot. I imagine it as something akin to you have a team of people shovelling to fill in trenches, and a team of people right next to them digging trenches. To date I have not seen a lube with this claim test well for outright efficiency, nor seen obviously better longevity rates. One will note this is believed to be different for claims re wax (paraffin, Molten Speed Wax, Ceramic Speed UFO and UFO drip lube) where it has been tested and proven that wax increases in efficiency and decreases in friction whilst being ridden in part due to wax surfaces becoming highly polished so one has two super slippery solid lubrication layers sliding against each other – contamination free. The two conflicting teams of trench fillers / diggers is largely negated as the vast majority of contamination simply bounces straight off the chain, whereas with a liquid lube contamination is immediately absorbed by the liquid and is now able to abrade against whatever surface it is in contact with every articulation.

Another claim under this banner is that they “condition” the actual chain metal by polishing it to a smooth shiny surface. There is a high profile lubricant in particular that claims this, and it did not efficiency test well at all. It may well be polishing away the metal, but that would **have to take friction to do so**. You can’t polish anything with a frictionless substance. So the lubricant basically claims it is performing the duties akin to a very fine emery cloth, and even if it is super fine – it still **MUST** take friction to polish metal. Add a small amount of friction across multiple surface interfaces articulating 20,000 times a minute – and it is not surprising it friction tested right near the bottom of 55 lubes tested. (Again comparing to wax – wax is soft and becomes polished quickly and easily – but the fact friction typically drops by around 0.5w from when it starts the process to when it quickly finishes the process – it is still taking some friction to get from not polished to polished.

Polishing hardened steel – that is also often plated with specific hardened coatings like chromium carbide, titanium nitride, nickel, or a zinc alloy etc - would take somewhat more polishing than wax.

And yet again on this – surely in short order contamination will be scuffing and scratching the surface ceaselessly putting micro scratches back in. Attaining their smooth polished surface would be quite the ongoing tussle.

As yet I am not convinced “metal conditioning” is the best approach re achieving a high performance chain lubricant and I would have concerns paying big \$ for a lube in this category.

## **About Factory Lube**

A common mistake many people tend to make is to just ride factory lube and then start adding their lube of choice on top of that. Factory lube may feel good and smooth, but that’s simply because the chain has been immersively lubricated, is brand new, and so vs the old chain worn out full of grit chain you just took off, it is going to feel good.

But factory lubricants are not really designed to compete with the best chain lubes. Testing shows that in general factory lube tends to range from mediocre performance to frankly terrible. One can 2 to 5w just by cleaning off factory lube and replacing with even a mid pack lube.

Factory lubes also don’t tend to focus too strongly on contamination resistance – most gather a lot very quickly.

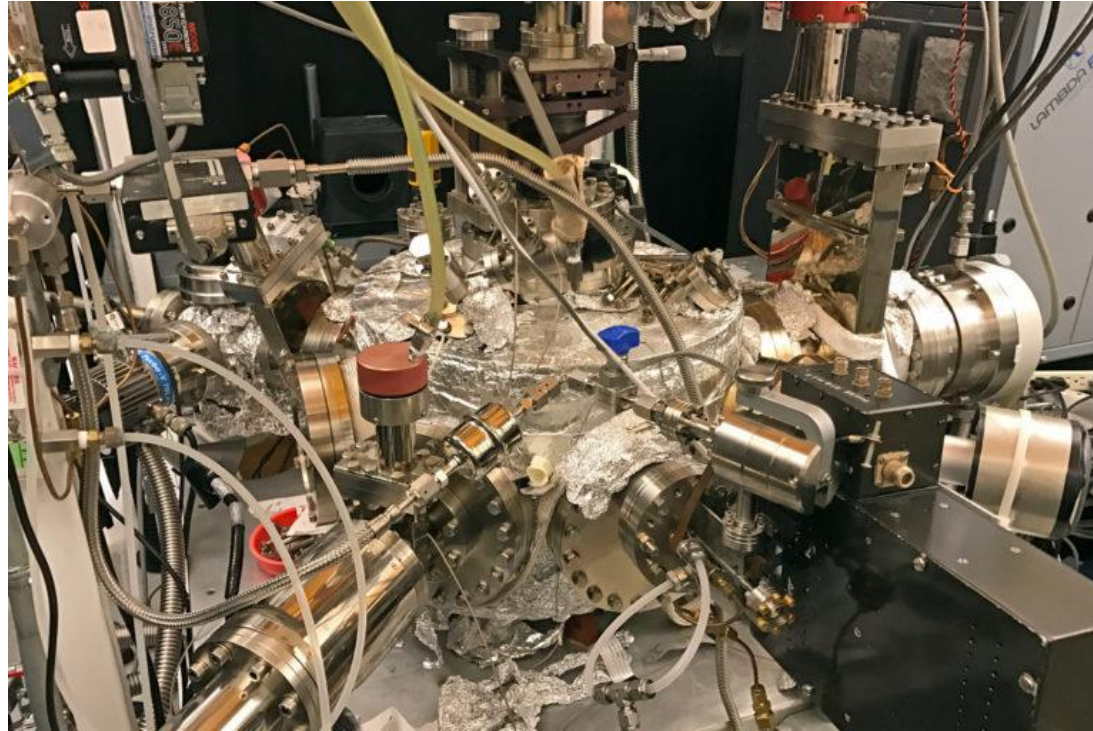
So riding your new chain with factory lube and then adding your selected drip lube on top – likely a completely different type of lube which may not mix well – can totally undermine that lubes ability to perform as per manufacturers claims. You will find a lot of manufacturers do state to apply their lube to a clean chain – but most cyclists either do not clean off factory lube, or perform a very inadequate clean such as wiping the outside / spraying on some degreaser and wiping etc – it takes a lot more than that to properly clean a chain.

***\*No matter what is your chosen lubricant – always properly clean off factory lube, and give your lube of choice a chance.***

***\*\*However – it is good to ride factory lube to “break in” new chain for 50 to 100km in clean conditions – and then clean factory lube off properly – especially recommend this for prepping race chains.***



## Latest Tech Lubes



(apparently the making of cyclestar nano tech lube...)

Since FF lube testing there have been a number of new high tech lubes released, and some exciting new ones are on the way. - Some of the new lubes from big respected companies will be claiming some pretty big performance, and I've seen a bit of snippet into some of them that have extremely good friction performance - on a clean chain. But the trick as always is how does a drip lube deal with contamination. Will we find one that stays close to waxing? Or match waxing? Or beat waxing?



A couple of the extreme high end drip lubes – Muc Off Nano and the just released Ceramic Speed UFO drip lube – are extremely fast drip lubes – both have actual proper friction testing equipment so there is actual testing of their performance. The key as always is how do they handle contamination. CS UFO sets to a proper solid so this bodes extremely well, Muc Off I am trying to find out a bit more but appear to be hinging on a very strong protective membrane that delivers extreme high pressure friction performance and be able to protect chain metal for a long time. They claim their lubricant withstands harsher conditions for much longer than any wax based lube or solid wax – so I am excited to see how this tests – as usual actual detail information on testing protocols is not available.

There is another one – Cyclestar Gold – with some rather big claims on tech and performance but with NO data to back up, and if one writes to them (and Im not the only one who has) to ask questions re data and performance – they simply do not answer back. Funnily enough they include a letter with the purchase in case you are interested in being a retailer – so they are happy to talk to you then, but look for some data to back up the big claims and your enquiry is simply consigned to the waste bin. An interesting approach. Here is high tech company boasting about the amazing tech used to create the best lube ever - you would think they would want to talk your ear off about how they ascertained these results to back their claims. I find it odd in the extreme they flat out ignore any correspondence re testing and performance. So that will be interesting to test but for the price and claims their approach to questions is not confidence building. *(Just for fun It is also worth noting all their laser crafted low friction tech is suspended in mineral oil. High grade mineral oil tests at 6w efficiency @ 250w, Cyclestar tests at 7w. So at a quick glance one could be forgiven for thinking a lot of tech has gone into finding a way to make mineral oil slower. And mineral oil is not great on the gathering and dealing with contamination front – so it is hard to see how all the super tech suspended in the mineral oil won't also be negatively affected by contamination. At \$60 for 30ml delivered to my door, I really wish they would answer my questions.*

## **Careful correlations...**

The longevity testing performed here hinges on the correlation between abrasive wear of the pins / plate shoulders and rollers. If a lube was frictionless and remained frictionless, these parts would not wear, and chains would not “stretch” and last forever. There are a number of components of friction in a chain (to properly understand you really need to read full test brief, or at least Friction Facts White Paper – this is just to cover a little for those who haven’t / won’t). There is high pressure friction between pins / plate shoulders / rollers under direct rider load. There is same but low pressure friction as links snake through derailleur pulleys. There is viscous friction as the links articulate, and there is static friction (stiction) as links constantly need to start moving from a static position. And this is happening in around 40,000 friction points per minute. There is so much mechanical work being done by your chain that this is why chains and lubes are where it is at for the biggest and easiest watts savings vs bearings that spin lazily in a sealed environment.

In outright efficiency tests on a clean chain in a lab – the percentage of the overall friction equation that low pressure friction, viscous friction and static friction play will likely be a much greater percentage than on a contaminated chain. On a contaminated chain where the high pressure friction movements are being performed with a lubricant that is now abrasive to some degree – this part of the friction equation will likely grow and grow over “X” km to overshadow the other aspects re overall efficiency being delivered. And it is the high pressure abrasive friction aspect that is responsible for the vast majority of chain wear as it is this that wears the pins and plate shoulders thinner and roller bores bigger.

**Hence a lubricant simply cannot be a high efficiency lubricant out in the real world if it is eating through hardened steel parts at a prodigious rate.**

Out in the real world different lubricants gather contamination at vastly different rates – are they solid? Contain mineral oil? Carrier fluid with solvent that dries to some degree?

How do they handle the contamination they gather? To what degree do they actually “clean” as they lube, or form protective films / membranes?

So a lubricant that tests well in a lab can start acting like a bastard file in short order once ridden outside. Or one that tests quite mediocre may remain similar to that level for an impressive period slowly changing to something more akin to a mild emery cloth. The mild emery cloth is going to be a lower friction lube with lower chain wear rate than the bastard file and be a better choice of lube unless your race is a short race being held in a laboratory.

However – it is possible that a lubricant can exhibit excellent longevity results but still be a relatively poor efficiency lubricant. It may simply perform poorly in viscous and static friction. An analogy would be heavy duty grease in bearings – it may exhibit excellent bearing life, but fast and high efficiency it will not be vs time trial grease. So the worst efficiency lubes on the FF testing – is it simply that high static and viscous friction contributed heavily to this result and is not necessarily a predictor that it will have a poor longevity result? – that will depend on how well it goes re gathering and dealing with contamination, how abrasive it becomes and its high pressure friction performance. \*Maybe it will be like a heavy duty grease and deliver an excellent longevity result – but in this case we know from the efficiency testing this does not translate to a fast lube. It is possible it may be a good choice for your commuter bike etc. Or maybe it will return an average longevity result and so overall just have not a lot going for it.

*(\* we say maybe as stereotypically lubes with poor static and viscous friction are a heavier viscosity wetter lubes, and these tend to gather and hold a lot of contamination quickly. They can be great for riding for hours in the rain and muck and chain still be “lubricated”, but the lubricant can literally become like sandpaper. There is often a big trade off between outright longevity of a lubricant and how contaminated it does or does not become).*

So what we are looking for are the best lubricants that have high outright efficiency and if used and applied correctly as per manufacturer’s instructions deliver impressive wear longevity results and stay very clean. This demonstrates that it does not become notably abrasive and have a big decline in high pressure friction performance - therefore retain great efficiency levels outside the lab.

Where possible we will match longevity results with outright efficiency results if known and freely available. If a lubricant achieves excellent longevity results in our test here however is matched with a fairly medium or poor outright efficiency result – maybe that is good choice of lube for your training bike / commuter but not your race bike / race chain etc.

Where lubes do not have readily available data we will work with manufacturer to see what we can get, and / or try and twist FF arm to test – sometimes they still can't resist ☺

I have asked Friction Fact re testing our chains when they have reached their end of test mark, as that would complete the circle of knowledge – clean chain efficiency, longevity result, end of test contaminated efficiency result. At the moment – the answer is no due to conflict of interest – but I will keep asking, and I will keep all end of test chains in hope of this situation changing in the future.

## **A bit of a wrap!**

- Be wary of “cleans as it lubes” claims – there is huge variability in performance, and a rather loose definition re “clean”.
- Be wary of “forms a protective film / membrane” claims. Again – huge variability in performance.
- Be wary of “conditions the metal” claims
- Current knowledge points to minimising the amount of contamination gathered is generally superior vs ways of trying to handle contamination gathered.
- Solid wax or drip lubes that dry to a proper solid coating have an advantage re contamination, as well as viscous friction (solid lubes have no viscous friction). Dry / Semi dry lubes that go tacky MAY perform well, they also may not.
- Be aware however that a poorly executed dry lube will not give these advantages – one is simply left with very little actual lubricant after carrier fluid has evaporated. They can have very short lifespan, high friction and high parts wear rate.
- Liquid lubes increase in contamination from km zero and the ratio of contamination to lubricant usually continues to build and build, although there are exceptions. Real world friction results will typically be much higher than clean chain lab test results – even the longest lab testing tends to only go to around 4 hours. The friction increases from contamination will correlate with increased rate of

chain wear. If a lubricant gathers very little contamination, and / or truly keeps contamination from acting against chain metal, chain wear rate will be low and friction increases vs its lab performance will low.

- Wax emulsion lubes that go semi dry or “plastic” may have excellent dry contamination resistance, however water will provide a medium for contamination to penetrate, and once in, they can have no effective mechanism of getting back out again. They can also take a lot of time and effort to properly prep after cleaning chain to ensure the viscous lube penetrates through to pin through the very small lubrication gap.
- A chains PTFE coating and any platings can be quickly compromised from abrasive friction leading to an increased rate of friction and chain wear.
- Solid lubricants gather contamination at vastly lower rates, and for a good period after each treatment have two solid lubricating surfaces sliding against each other preventing metal to metal and contamination to metal contact. Hence they can remain close to lab friction performance for an impressive period after each treatment and not begin increasing from km zero. In fact most completely solid wax treatments will show a decrease in friction vs lab tests after the wax has been fully broken in. Consequently they can also deliver extreme chain longevity by truly preventing anything actually coming into contact with chain metal. This is dependent on not exceeding the treatments lifespan for the conditions.
- Note however that solid lubricants – once all of the lubricant has been worn off- friction can increase quickly and dramatically. They need to be kept within the treatments lifespan and so may not be suitable for long wet events or enduro’s unless one is able to re-lube during event.
- To retain good performance most – but not all – drip lubes require frequent full solvent cleans to reset contamination levels in the chain or friction performance will continue to degrade. Some can have a frighteningly quick change in performance vs lab results, some will remain in the ball park of lab results for an impressive period – but without periodic proper cleaning a notable increase in friction and wear is usually inevitable.
- Some drip lubes – usually wax emulsion lubes – can perform better over time without cleaning due to building up of wax layers inside chain and low contamination gathering rate in dry conditions.
- These lubes can have an initial high wear rate due to poor initial penetration to pin through lubrication gap.
- These lubes can also retain high friction and wear rates post wet rides due to lack of vector to shift contamination back out, resulting in need to fully clean chain post wet rides to reset contamination – leading one back to initial issue of getting lube penetrating through to pin again.

- Consider the apparent “convenience” of drip lubes vs “inconvenience” of waxing application. Drip lubes are easier to drip on but require a large amount of cleaning time and care to remain remotely near lab performance, and drive train parts wear will range from poor to good – typically 3000 to 6000km to reach 0.5mm for most road cyclists. Waxing takes a few minutes longer to apply at the front end, however the performance is always very close to lab performance for the lifespan of each treatment, and no cleaning maintenance is required of chain and drivetrain which remain exceptionally clean. Each re wax – being fully immersive in hot wax - resets any small amount of contamination gathered and ensures complete lubrication to all surfaces of the chain. It is the only time re lubing properly cleans as lubes, your chain comes out like brand new every re-wax. Drive train parts longevity can reach simply must experience to believe levels. So for those who never ever clean drivetrain, then yes – waxing will add time. For those who try to stay on top of drip lube drivetrain, waxing usually saves a lot of time due to no cleaning of chain and drivetrain required, and it is always near lab test friction performance as long as kept within its treatment longevity limits.
- A dedicated race chain is a very cheap, smart and simple way of saving a stack of watts for events. This chain can be properly prepped and kept in a very low friction condition and with low wear, as opposed to rocking up to races on same chain that is hammered in training. It costs no more to pre buy next chain, and when training chain hits 0.5 wear, race chain becomes training chain, get new chain to prep for racing chain.

Thanks for reading!

PS - We love questions – so if you have any on any fronts – zing them through to [info@zerofrictioncycling.com.au](mailto:info@zerofrictioncycling.com.au)

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Summary of tests – full test protocol running sheets available on request.

## **Best articles to read!!!**

[http://www.friction-facts.com/media/wysiwyg/Friction\\_Producing\\_Mechanisms2.pdf](http://www.friction-facts.com/media/wysiwyg/Friction_Producing_Mechanisms2.pdf)

[http://www.velonews.com/2015/12/bikes-and-tech/technical-faq/technical-faq-chain-wear-measurement\\_390085](http://www.velonews.com/2015/12/bikes-and-tech/technical-faq/technical-faq-chain-wear-measurement_390085)

[http://www.velonews.com/2017/08/bikes-and-tech/ufo-drip-might-be-the-fastest-chain-lube-ever\\_446861](http://www.velonews.com/2017/08/bikes-and-tech/ufo-drip-might-be-the-fastest-chain-lube-ever_446861)

[http://www.velonews.com/2013/04/bikes-and-tech/velolab-revisited-testing-chain-friction-over-time-with-progold\\_282854](http://www.velonews.com/2013/04/bikes-and-tech/velolab-revisited-testing-chain-friction-over-time-with-progold_282854)

\*Note – msw tested at 4.6w on velonews / FF testing. Race chains with break in, ultrasonic cleaning, waxing, break wax in and powdering are something else again. Hence MSW race chains or CS UFO chains will make a lot of sense if you have read everything to this part as well as why we sell wax ☺

<https://cyclingtips.com/2016/05/friction-facts-how-lubricants-and-seals-affect-cartridge-bearing-friction/>

***Test equipment : Ultegra 11spd chain on shimano 105 11-28 cassette, Shimano 53/39 chain rings. Industrial 250w motor geared to 100 cadence, coupled to chain set axle. Tacx Neo smart trainer to control load- goal load per interval 250w +/- 2%.***

***Test protocol outline: (\*refer full test brief for full details). Test chain is shimano ultegra 11spd. Chain is initially perfectly cleaned with multiple agitated solvent baths, ultrasonic clean and methylated spirits + acetone rinses. All chains are measured for initial manufacturing tolerance across 7 separate sections of chain accurate to 0.01mm. All check measures***



at end of each test block are repeated the same. Simulations are run at as close to 250w +/- 5w resistance window as possible. Each block is 1000km – with both Flat and Hill simulation intervals in every block. Flat simulations are run on large chain ring and alternate through cogs 4, 5, & 6 (21, 19, 17t), hill simulations are run on small chain ring and work through cogs 1, 2 & 3 (28, 25 23t). Intervals on clean blocks are 400km for flat simulation, and 200km for hill simulation. Each interval runs for approximately 10 to 12 hours depending on ratio – and so each 1000km block approx. 30 to 32 hours. Lubrication is applied as per manufacturer instructions, and re-applied either at start of each new intervals as per test protocol (every 400km flat sim, 200km hill sim) – unless according to manufacturer instructions this frequency may be detrimental to performance - in which case re lube intervals will be adjusted and this noted accordingly. During contamination blocks - contamination introduced is sandy loam which is a mix of sand, silt and clay – wet contamination blocks also have water spray. During Dry & Wet contamination blocks, the interval lengths are halved (most cyclists would re lubricate more often if riding in harsher conditions – so every 200km flat and 100km hill simulations. Contamination is introduced mid interval – 100km mark for flat and 50km mark for hill. Extreme contamination block the amount of contamination is doubled, and this is also done twice per interval vs just mid interval. If a lubricant specifies / recommends drying time before riding – this is done – all manufactures instructions are closely followed. Blocks of no contamination are alternated in with blocks of contamination to give lubricants the best chance to prove any “clean as they lube” ability – a common lubricant claim. Contamination is introduced in both dry and wet format – dry the contamination is 5grams of sandy loam released at a controlled rate over the chain whilst running via small nozzle, wet is 500ml of water sprayed at low pressure onto running chain, and 5grams of sandy loam added. During extreme contamination block the amount of contamination (wet and dry) is doubled, and the frequency it is added is doubled. Km's achieved in this test should in no way be interpreted as km's you can expect to achieve in your own riding as the power and contamination you subject your chain and lubricant to will be different, as may be your chain and drive train maintenance – it is expected most should achieve more km's vs this test – the test averages higher watts than most, there are no rolling or descending km's, an overall level on contamination may be higher that what your chain is exposed to. Note this is road simulation and will not be able to be equated to mtb and cx km's as they eat through chains much much faster. The extreme contamination

*protocol is more akin to tough off road conditions – however not all lubricants will be test through that protocol if they have not made it that far into the test – if the amount of wear from other blocks has been sufficiently high, it is not going to be a lubricant suited for harsh conditions riding.*

*\*To properly understand testing and results strongly recommend reading Test Protocol Synopsis as a minimum, better yet is to read full test brief and friction facts white paper – you will learn a lot about your most crucial component & its lubrication – it will save you both watts and running cost \$. Full Test protocol running sheet for each lubricant tested is also available on request. All docs freely available from lube test section on [www.zerofrictioncycling.com.au](http://www.zerofrictioncycling.com.au)*