Zero Friction Cycling

Key Learnings from Lubricant Testing- Round 1

First a quick intro / re-cap on the testing project.

Cycling consumers - like most consumers, are faced with difficult product selection choices. Cycling product manufacturers need to make money. To get as many consumers as possible to buy their products vs a competitor, a lot of effort and resources goes into marketing. The product claims stated on the item together with brand name and price are often the key determining factors that drive consumer purchasing decisions. And for cycling – what the top world tour teams are using counts for a lot too, irrespective of whether they have simply been thrown a mountain of $ to use a particular product vs using at the top level because it is a genuinely great product.

As with all markets, cycling consumers face an age old problem – how true are the performance claims made by the manufacturer?

Here are a few quick facts regarding chain lubricant choice;

- There are literally hundreds of products and brands to choose from.
- Not one of them states on the bottle “this is a really average product that doesn’t really do anything special” or a derivative of this.
- The majority will claim performance attributes that are extremely difficult to achieve, such as “cleans as it lubricates”, “Repels contamination”, “conditions metal”, “forms a protective film against contamination” to name some of the most common.
- Very few products really perform as claimed with regards to the above criteria.
- Like all crowded markets, there are some outstanding products, a lot of average products, as well as a not insubstantial amount of very poor performing products.
- The very poor performing to the average to the outstanding will all be making similar marketing claims.
- You are unlikely to be able to tell from product type, brand name, price, or manufacturer claims if a product is going to be high performing, average, or poor.
- **Performance claims backed by manufacturer testing rarely passes scrutiny with regards to how the testing was conducted and data obtained. Most will run for hills when asked for specific data or test information, which is odd behaviour indeed. Have a great product and robust objective testing data to prove it – the manufacturer should be shouting it from the rooftops to all who will listen.**

In my learnings from lubricant testing round one, here is a quick analogy of what I have often come up against in my communication with manufacturers. Let us pretend you have just walked into a prestigious car show room.

Sales person - " This is the most powerful AND fuel efficient car in world"
You : "Wow. That's amazing. What are the figures"
Salesperson - "It is around 2000 horsepower and uses 1 litre of fuel per 100km"
You: "Awesome! How did they achieve that?!"
Salesperson - "It's a revolutionary formula that repels friction and fuel consumption by having ceramic nano particles on all moving parts in the engine"
You : "Far out. So how did they measure the average fuel consumption? Is that city or country driving?"
Salesperson – stares at you in silence.
You: "What is the 0 to 100kmh time with all that horsepower?
Salesperson – Stares at you in silence
You: "I've been to 3 other car yards before coming here and they also all claimed they had the most powerful and fuel efficient engines in the world – I'm a bit confused as to how everyone is making the same claim?"
Salesperson – Turns around and walks away, locks himself in his office, and refuses to answer the door. If you ever walk back into car yard he runs into his office and locks the door.

The above behaviour analogy could be applied as a summary of my communications with Cyclestar Gold, Muc-Off and Wend Wax, as well as numerous manufacturers I have conducted initial investigations regarding lubricant to see if based on claims I should add it to my test list in the hunt for genuinely great products to stock.

Even worse – testing may have been conducted in such a manner that provides highly misleading results. Think Volkswagon and Diesel-gate. Unfortunately we may have our very own case of this (refer to my investigative document **– Fact Check – Manufacturer testing** which covers the many unanswered questions re Muc-Off testing data). The short version is – in this day and age of fancy test equipment one would have hoped that we now have black and white test data to back manufacturer claims – however testing can be all to easily skewed and so material from some manufacturers making a seemingly powerful case to support their product may in fact be muddying the waters even more.

https://zerofrictioncycling.com.au/wp-content/uploads/2018/07/Fact-Check-Manufacturer-Lubricant-Testingv3.pdf

On the other side of the coin however, manufacturers who have worked hard to deliver a genuinely great product to market typically do match expected response

when dig behind the claims, which makes logical sense. If one has done robust, honest testing and they know they can stand behind their product, one finds they are very excited to be asked about it and are not afraid to answer detailed questions with more than just marketing fluff. If a manufacturer runs for the hills when asked on what testing and data sits behind claims, or the testing has serious questions to answer and they are unwilling to answer them, this is a bit of red flag indeed – it makes no sense not to provide irrefutable proof re how your product claims are backed to all whom are interested.

Objectives for ZFC Lubricant testing

- Hunt for genuine best in class lubricants so I know whom to highlight and what products to try to stock.
- Put to the test lubricants with biggest and boldest claims and / or potentially exciting new technology / approach to the challenge of lubricating an external component completely exposed to contamination.
- Understand what sits behind the performance of lubricants that test well, especially if test results closely match manufacturer claims.
- Gain insight as to why lubricants that made big performance claims tested poorly and give those manufacturers an opportunity to substantiate their claims and counter ZFC test results.
- Fill the void left by Friction Facts re independent testing after FF were purchased by Ceramic Speed.
- In time have manufacturers use the information from ZFC testing to aid in product development.
- Bring accountability into an area of the industry that has been able to claim and print whatever it likes for too long, and bring some accountability to manufacturers whom to date are simply able to avoid any pesky questions that dig behind the marketing hyperbole. Great products / manufacturers should be highlighted as such, as should concerning products / manufacturers. There appears a bit of trend with many of the best products flying under the radar and struggling for a place in LBS shelves, whereas a number of the worst performing are powerfully marketed and have the red carpet rolled out for them at LBS. Sometimes it could be a double whammy factor of a) those that invested heavily in product development are a small company and have a smaller war chest left for marketing, and b) some of the poor products likely had very little spent on development, making a grat product wasn't the key mission – exploiting an attractive sales angle was (ie a rub on coloured wax….) so the marketing department has a very healthy budget – especially if it is from a big market player.
- All of the above done to assist both cycling consumers with their purchasing decisions that achieve low friction, low maintenance, clean running drivetrains with

greatly reduced drive train running costs, whilst at the same time testing being self funded via directing ZFC regarding product stock selection – negating the need for testing results to be put behind a paywall.

At the time of writing this document, the above objectives have been largely achieved after round 1 testing, and things are shaping up for a very exciting round 2 testing as soon as Chain Longevity Test project is completed.

A number of major manufacturers have booked in to have their products tested and benchmarked as part of their products development - however some test results will not be for public release as tested under Non Discolure Agreement.

It is heartening indeed to see a number of industry leading manufacturers genuinely working very hard to bring ever improved and very high performing products to market, and that these manufacturers have been on the lookout for independent testing to help validate their own testing. A number of the key difficulties with lubricating a component completely exposed to contamination are being tackled from some new and innovative fronts that I look forward to sharing more about when I am allowed to release information from NDA testing.

On the other side of the equation, it has also been disappointing to see strong market penetration of some frankly horrific products off the back of clever marketing. In one case all it has taken to execute strong market penetration has been to introduce some gimmicky colouring.

Considering the cost of latest top tier drivetrain components, ripping through them due to poor lube choice = ouchies re bill shock. Also rocking up to a race with 5w more friction in your chain than a competitor despite the fact you believed you shelled out some good coin to achieve a low friction chain isn't really a great consumer outcome either.

Facts are rather important. There are great products out there, terrible products out there, and a whole big beige area of meh in between. The best products will not only save you a great handful of watts in your drive train, but also deliver the lowest running costs due to lower friction eating through your drive train components. Win win indeed. The worst products deliver you the opposite on both fronts.

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The cost of many of the top tier group set components is such that the difference in running costs between a high performing lubricant vs a poor performing lubricant can be many hundreds to even thousands of dollar's over 10,000 to 20,000km of riding. A poor lubricant can eat through chain, cassette and chain rings within as little as 2000km vs the highest performing that will hit an early chain replacement recommendation mark at around 10,000 to 15,000km - whereby one can get a second chain on same drivetrain components without issue and run another 10,000 to 15,000km.

When cassettes can cost upwards of $700 and chains $150+, and now with sram we have both front chain rings and spider as a single very expensive unit – running a lubricant that delivers outstanding drivetrain parts longevity has never been more important, even for those who do not race.

So friction savings for racing / sportif's aside, a poor lubricant can have your bicycle costing a similar amount to run per km as a Ferrari, or you can have the beautiful top tier component spec bicycle you coveted zooming along like silk for years with impressively low maintenance costs. This means a lot more money in your pocket that can then maybe go towards other very cool things like a second set of wheels, or new helmet and lights, or N+1……. Many other fun options can be on the table if your wallet isn't being sucked dry by a product that promises the world but in effect lubricates about as well as a cutting fluid. Multiple bike households, partner who rides etc – the difference that a great vs poor lubricant can make to one's budget is often never properly considered.

Hence why over time as ZFC profile grows we would like to see a greater % of the market much better informed, it is just such a crucial area that has not been given the front of mind time it should have - yet.

It is time to shift lubricant choice right up to top of the list consideration.

And having taken the time to consider lubricants properly, you can also play a big part in helping bring more accountability to manufacturers and stores by voting with your voice, your feet and your finger tips.

Why is your LBS stocking X that will eat through your drivetrain like a sandblaster, and not stocking Y which will have you very happy for a very long time? Most times it is as simple as they run with big name stuff, on trend stuff, and they just run with manufacturer claims.

But this isn't always the case. I have literally seen first hand where stocking of a top lubricant was rejected out of concerns re selling less drive train components due to increased parts longevity, and the red carpet was rolled out for the worst lubricants tested to date.

On the other side of the coin, I recall one store owner commenting on a ZFC facebook post they refused to put the wend sample pack out for sale as they had concerns re what it would do to customers drive train. Highly commendable behaviour, and hopefully commonplace with good LBS.

I operate on a simple theory – look after your customers with best products and service you can, and they will look after you. Some local bike stores follow the same principal, others do not. If you have concerns, ask your bike store about it. If they are clueless regarding a products actual performance (the most likely case as to why they are stocking a poor performing but well marketed product) refer them to ZFC website for information. Or send them an email advising them with a link to ZFC. Vote with your feet, finger tips and wallet as to where your hard earned dollars go. Most business behaviour will quickly follow where the money flows. If everyone who walked into an LBS asked for a bag of MSW, or bottle of NFS or Smoove, and avoided buying a coloured rub on chain eating product or a hydrodynamic cutting fluid, many stores would quickly change what they stocked. As consumers you have the most power to effect change, not one little ZFC website. ZFC can help you with independent information, then you have to choose how you act on that information. Help reward your LBS / favourite online store for stocking great products and avoiding terrible products that will deliver a poor and expensive user experience.

Remember too often the best products are fighting to get a space on shelves. If that space is occupied by a poor but powerfully marketed product, it is very difficult for the great products to get a spot. You can change this.

*(*Disclaimer – ZFC is the Australian importer for MSW as I was lucky enough that no one else had snapped that up yet when I discovered years ago the wonderful world of immersive waxing. However re Smoove, NFS and UFO D - online stores and LBS do not purchase from ZFC but either direct from manufacturer or from a different Australian importer. So aside from stocking myself as they are great products – all other outlets are purchasing these products directly from the importer / manufacturer and therefore ZFC has zero financial interest in those products greater market penetration. In fact – the more outlets that sell them, the less likely the sales may come in ZFC direction. ZFC is completely independent regarding what products are recommended / stocked and what products are not. ZFC is also beholden to no manufacturer and can and does change product selection and recommendation should a higher performing product in that line become available).*

Most common marketing claims vs reality

Alright, mini manifesto out of the way – let us look at a few cold hard facts with regards to the challenges of lubricating a very hardworking mechanical part that is completely exposed to the elements.

To get your mind in the right zone here – imagine if you will removing all of the weather and dust seals from your wheel bearings and bottom bracket bearings. After just a few hundred km's, you can imagine how they will be running and feeling. The bearings will feel and sound gritty / crunchy, be running rough, and surfaces already damaged. The situation will continue to degrade in cascading fashion as you continue riding with bearings open to the elements and contamination.

Now imagine that seals and dust covers for bearings are outlawed, you can't use them period – bearings have to run completely open. So now we have the challenge of making a bearing grease / oil such that they are somehow able to remain grit and contamination free and remain running silky smooth.

That would obviously be quite a challenge.

How would a grease or oil not have airborne dust and contamination stick on contact and become blended in with the lubricant?

Would a grease really be able to repel contamination?

Would it really be able to "clean as it lubes" etc?

Tall order.

This is exactly the challenge faced by chain lubricants. Except – the results are even more critical as chains are more exposed and work much, much harder than bearings. It is an extremely difficult challenge that most of us don't really consider. We drip a lube on, it goes black, we "maintain" it to some degree when we can – a continual battle against a black mess and chains / cassettes wearing out in around 5000km is just the way it is.

You would not dream of taking seals off your bearings and riding around, yet do not think twice about the black mess coming off your chain and the friction + drive train running cost consequences this has.

Because of the environment chain lubricants need to operate in, many manufacturers make some lubricant performance claims that are extraordinarily difficult, if not nigh on impossible to achieve.

And as is the way with marketing, when manufacturers A, B, C start claiming amazing attributes for their lubricant, and able to do so without the need to provide any substantiation of these claims whatsoever, then everyone else simply follows suit so as to keep up on the marketing battleground. This sure make's things tricky for consumers.

Let us take a quick look at a couple of the main stereotypical claims;

"Repels dust / grime / contamination"

If you drip on a lubricant that is a particular colour, go for a ride, and what is coming off your chain is now black in colour - it has absorbed dust and contamination, it has not repelled it.

Shine a bright torch into the air at night and you will be surprised to see just how much airborne dust floats through the beam. This airborne dust will stick on contact with a liquid. You can perfectly clean your chain, and with most lubricants go for a ride for an hour, on your ergo, indoors – and the lubricant will now be black. Is that really repelling dust?

Again I refer back to removing seals off your bearings. If you were to go and do that right now, even on bearings that have been running in your bike for a year, you will usually see the grease inside is white in colour, or blue. It is still the same colour as what was put in bearing at the factory or last service. Leave the seals off and go for a ride or two, and you will see the grease is now black. *(*This may be an expensive experiment as you will likely now need to replace said bearings. You may just want to trust me. And logic*).

It sounds great, so pretty much every chain lubricant claims it, and some of the very best lubricants do resist dry contamination impressively well, however for the majority this claim and reality are rarely hanging out in the same universe.

"Cleans as it lubes"

Depends on your definition of clean. If by adding 5 to 10ml of lubricant which ***may*** dilute and flush out a very small amount of contamination for a short period = clean for you, then ok sure – it cleans as it lubes.

However, if you were to remove chain and agitate it in a container with 200ml of mineral turpentine – the turps would instantly go black. Pour out, and repeat, and turps will instantly go black. Repeat, repeat, repeat, and somewhere around two to three litres later, the turps will be coming out similarly clear as what went in. Now the chain is clean. So if it takes litres of solvent to fully flush clean a chain, there is a limit as to how much adding 5 to 10ml of lubricant can do, and that limit is pretty darn low.

Imagine a big sink full of filthy water from washing up after a wedding party. Turn the tap on for 5 seconds whilst simultaneously pulling the sink plug for 5 seconds, before putting plug back in and turning tap off. Is the water the in the sink now clean? Hopefully that helps paint the picture.

The only lubricants I can be confident in stating have some effective ability to clean as they lubricate are those that set truly solid such as Molten Speed Wax and Ceramic Speed UFO Drip - as they are a shedding type wax / coating. This means abrasive contamination will physically abrade away the wax, often taking itself out of the chain with it. This keeps solid lubricant treated chains very low friction in harsh conditions for a period of time. Not only do they resist gathering contamination to a vastly greater degree being solid vs liquid, but they also have some ability to shed contamination that does penetrate when it abrades the solid lubricant off.

This shedding/cleaning does come at a cost of treatment lifespan, as the lubricant layer is being physically abraded off in the process. As long as the ride / event is within treatment lifespan for the conditions – then friction and contamination levels will remain impressively unperturbed by the contamination being thrown at it. However - exceed treatment lifespan you will have the paradox of very low friction lubricant that remains very low for "X" period, then a rapid increase once the lubrication has all been abraded off. Depending on the length and conditions for the event can mean weighing up lubricant choice.

One of the original lubricant tests of paraffin back in the early days of Friction Facts and Velolab demonstrated the above perfectly. Here is an excerpt from their simulated longevity test which had chains running on machine for an hour dripping water and abrasive contamination on.

"We tested 8 of the lubes for longevity, simulating a single dirty wet ride and testing efficiency before and after. Each of the 8 was chosen as a representative of a certain lube type. For the most part, four of the eight, representing greases, wax based drip lubes , regular oils, and biodegradable oils, were all very similar, losing about 2 watts over the hour long test.

Once again the old technology of paraffin wax vanquished all comers. In the longevity test it was completely unperturbed by water, sand and dirt"

Link to article here - https://moltenspeedwax.com/pages/velo-lube-test-1

Also with a product like Molten Speed Wax - as that is an immersive re application, the chain is reset back to near zero contamination again simply by re waxing, all parts of chain are now re coated in a solid super slippery wax basically leaving chain metal out of it. For "x" km's after every re wax there is in most cases effectively zero chain wear. *(*note - over time as each re wax will introduce a very small amount of contamination into wax pot, the wax going onto chain will slowly contain more and more contamination – hence the recommendation to change wax after a certain number of re waxes to fresh wax. It takes a very long time though for the wax to even remotely approach the abrasive level most drip lubes attain in short order).*

UFO D - to keep at optimal performance will still require full flush cleaning maintenance however will remain vastly cleaner and low friction / wear for longer vs other drip lubricants due to setting to a true solid coating and being a shedding type lubricant. UFO D is the currently the closest a drip on lubricant has come to matching immersive waxing.

As a wrap for this section though, for drip lubes in general the clean as it lubes claim is not really upheld to even the loosest definition of clean. I await being proven wrong, if I am I will stock in a heartbeat.

"Forms a protective film / membrane"

With regards to preventing metal on metal contact – initially yes – many lubricants can achieve this, and should they remain contamination free – continue to achieve this. However once the lubricant becomes contaminated – which with exposed drip lubes is very quickly – this attribute will be compromised. The membrane is formed from the lubricant. As the lubricant becomes a black contaminated mess, thus any membrane being formed will also contain abrasive contamination. This contamination will now be abrading directly against chain metal.

If you try to imagine dripping some clean lubricant onto a chain containing black, contaminated lubricant, and the new lubricant passes through this without becoming

contaminated itself, then forming a clean contamination free membrane that is now protecting chain metal – that's quite a stretch. Again considering the general chain wear rates of drip lube's making said claim are no different to other drip lubricants in general, there is not much evidence to suggest this claim is able to be physically executed in an environment where the lubricant will be quickly contaminated. If the lubricant was sealed from contamination, the claim may well be true and remain so – but that is not the application for which the lubricant is being used.

"Conditions chain metal"

There are a few lubricants that claim to "condition" chain metal via one form or another. Some claim they polish metal surface to rid surface of micro fissures / rough surfaces. Others claim to fill in micro fissures etc.

There are a couple of questions that arise intuitively with such approaches, and again anecdotal results (and there has been some testing done for the highest profile metal conditioning lubricant) do not support the effectiveness of this approach.

For one, polishing hardened steel would flat out take friction. If you set to polishing something with a frictionless cloth, nothing would happen. So some amount of friction simply must be introduced if you are trying to change the surface condition of hardened steel. This is likely why the most prominent of this lube type (Pro Link Gold) didn't do too well in Friction Facts testing – coming in at 50th place out of 55 lubricants tested re outright efficiency. That's……not great.

Also, outside the lab, as soon as contamination becomes involved – which is immediately – you now have abrasive particles scuffing the surface the lubricant is trying to polish all nice and shiny or fill in.

It is akin to having having a team of people working hard to fill in a trench, whilst next to them is a team of people digging a trench. It is a bit of zero sum game approach. It is one that may (emphasis on "may") work in a clean lab, but rarely is our riding and racing held in a clean lab. Perhaps in the future Zwift will hold virtual races in Biohazard level 4 clean rooms and really open up lubricant choice, but until then – we should select products that have been proven to work in the environment they will actually be used in.

Here is a bit of an excerpt from Lennard Zinn of Velolab from some actual testing performed on the leading metal conditioning lubricant – Pro link gold.

" A ProGold employee once explained to me that ProLink is a "metal conditioner" with this effect. He told me that if you were to look at the surface of the metal in a chain with a high-powered microscope, it would look like the profile of the Pyrénées, rather than the smooth surface it looks to have without magnification. He said that, with frequent, regular use, ProLink would, over time, smooth those peaks down so the chain would run with lower friction. The ProGold website currently only says that ProLink "utilizes metal friction reducer technology.

Further in article;

"*The frictional drag results in the VeloLab test on the new, clean chains lubricated with ProLink, of which one chain was a SRAM PC1091R, were always below eight watts, and the average was 7.23w. However, our results for the used chains lubricated over time with ProLink were always above eight watts.*

This indicates that the chains do not run faster after long wear with regular ProLink application than they do when new and lubricated with ProLink"

Further in the article;

When we added ProLink to one chain, the KMC, while turning without load on the test fixture, the drag dropped by 0.42w, from 8.58w to 8.16w. When we subsequently lubricated that same chain with the second-best-performing lube in the VeloLab test, the Rock and Roll Absolute Dry, that same chain dropped by almost two more watts, to 6.33w. (In both cases, we just dripped the lube on; we did not do any chain cleaning.)

Link to full article: - https://www.velonews.com/2013/04/bikes-and-tech/testing-chain-friction-over-time-with-progold_282854

In summary – take any lubricants claims to "condition chain metal", either by polishing down peaks and or filling in troughs – with a very big grain of salt. Perhaps take it with an entire salt lake.

"Dry Lubes"

The appeal for dry lubes is strong as they generally stay very clean, and many like a clean looking drive train without needing to clean after ever ride. There are some exceptions, however in general as a group, dry lubes tend to friction test poorly, and by a big margin. Subsequently they also tend to deliver the fastest wear rates.

Most dry lubes are a small amount of actual lubrication in a solvent carrier designed to evaporate leaving just the lubrication behind.

The problem is most dry lubricants contain so little actual lubrication that whilst they look clean, the beauty is only skin deep as lubrication level is very poor and wear rates subsequently very high. I have had a number of customers hit with quite a case of bill shock by running dry lubricants, with chains worn well past 1% wear mark resulting in chewed out cassettes and chain rings in as little as few thousand km's. Not cool.

Some can be ok as long as you drizzle half a bottle on every 60km, but then you end up spending a fortune on lubricant even if the cost per bottle is fairly cheap.

In general – avoid. There are vastly better options. The only truly dry drip lube I know of that you can depend on at the time of writing is UFO Drip – but that isn't cheap and I don't believe was made as an every day lubricant, it is more a race day / dedicated race chain lubricant.

"Ceramic / Nano lubes"

This you can very much just place in the marketing hyperbole section.

Nano simply means very small particles. In effect, all lubricants contain nano particles, they are all nano lubes. It just sounds cool so a manufacturer will claim one particular component or additive as a "nano particle" to make it sound enticing.

Ceramic – Ceramic is very hard. It is hard to imagine how adding lots of very small very hard particles to your liquid lubricant is going to help, and I have seen no evidence from any front that it does. I have come across some reading that claims it is likely to be detrimental as the ceramic particles will be abrasive. Why not add some iron filings?

Intuitively it makes sense that ceramic lubes will more likely to be poorer performing in outright efficiency and wear vs lubricants without adding millions of tiny very hard particles. I just have not seen any evidence in either Friction Facts testing nor customer chain lifespans that has ceramic lubes delivering anything clearly in the high performing category.

Again almost all of the big name brands will have a ceramic lube in their line up because it sounds cool and their competitors are doing it.

Here is a snippet of the marketing claims from Finish lines ceramic wet lube;

Ceramic Wet utilizes a patented boron nitride technology. As the first bike lube company to innovate with ceramic particles, Finish Line has set new standards for race day lubrication. Ceramic Wet is changing the way many mechanics prepare their rider's bikes for race day.

In Friction Facts testing Finish Line Ceramic Wet lube is in 21st place out of the lubricants tested. To just what degree does a 21st placed lube change the way mechanics prepare their riders bikes for race day? This isn't to pick on Finish line as in general I think they make some perfectly fine (if nothing special) lubricants – it is just an example of the level of marketing consumers are faced with.

Personally I am not going to race on the 21st placed tires, nor the 21st placed bearings. Similarly im not going to race on the 21st placed chain lubricant, nor expect that such is setting mechanics worlds alight.

Most marketing is very convincing on the surface – that is marketing's job. Most big brands have big marketing departments, and as such products are cleverly and powerfully marketed.

It is important for me to note here that this document isn't saying the above product from Finish Line is rubbish, that its performance doesn't match claims, or you shouldn't buy finish line. It is just to highlight that as yet I haven't seen data to make me think I should jump on the product as per the marketing.

And I believe if data is there to back claims, manufacturer should provide it up front. Along with the full details of robust test protocol used to obtain data to back up claims. This doesn't seem to happen much.

Our perceptions of chain lubricant performance have been conditioned over time.

When it comes to bicycle chain lubricants – I believe there is simply a broad acceptance that a lot of black stuff is going to come out of our chain (despite dripping a clean fluid on), and that wearing out a chain to recommended replacement mark in around 3000 to 6000km is situation normal – it just is how it is.

Many do not wonder if there is much difference in the efficiency losses between one lubricant and another, and if they do, they believe the difference will be small. As long as I am buying some kind of ptfe / ceramic / nano / something / something lube from a name brand they are all going to be around the same mark and be a good lubricant right?

Whereas there are others who have never really been satisfied with the level of mess / wear rates and have tried one lubricant after another before settling on something that appears to be the “least worst” of all they have tried. Some continue the hunting, others give up and stick with their “least worst” find.

However the reality is the efficiency differences between different lubricants can be, and often is – huge. There can be up to 5 watts difference between the highest performing chain lubricants and worst performing – and that is on a perfectly clean chain in a lab at 250w load.

Factor in the vast differences in contamination resistance or absorption, differing levels of chain and drive train maintenance, and real world differences between chains can easily be 10w+. There are cyclists using –unbeknownst to them – a poor performing lubricant and with average attention to maintenance who will literally be running a 15 to 20w loss chain at 250w load, vs cycling buddies on a top performing lubricant with good maintenance sitting anywhere between around 5 to 8w loss.

As chain friction losses increase almost linear to rider load, that efficiency gap will nearly double every 250w extra load input. So a 10w loss chain at 250w load will be around 18 - 19w loss at 500w load and approximately 26 - 27w loss at 750w load etc. Versus a 5w loss chain which will be circa 8 - 9w at 500w load and 12 - 13w at 750w load – that efficiency gap is going from large to huge.

Hit a short power climb and attack at 750w, having 26ish watt loss chain vs a 12ish watt loss chain – I know what I want.

Racers can spend hundreds or thousands of dollars on ceramic bearing upgrades across the bike to save a few watts, and yet in many cases they could achieve many more watts savings simply by knowing what lubricant to buy, staying on top of good maintenance and or having a dedicated race chain that is kept in mint condition.

But as mentioned before it gets even better. Considering that in general you can expect the extra friction losses of a poor lubricant to contribute directly to faster wear rates of your drive train components, it is a double whammy in one direction and a double win in the other.

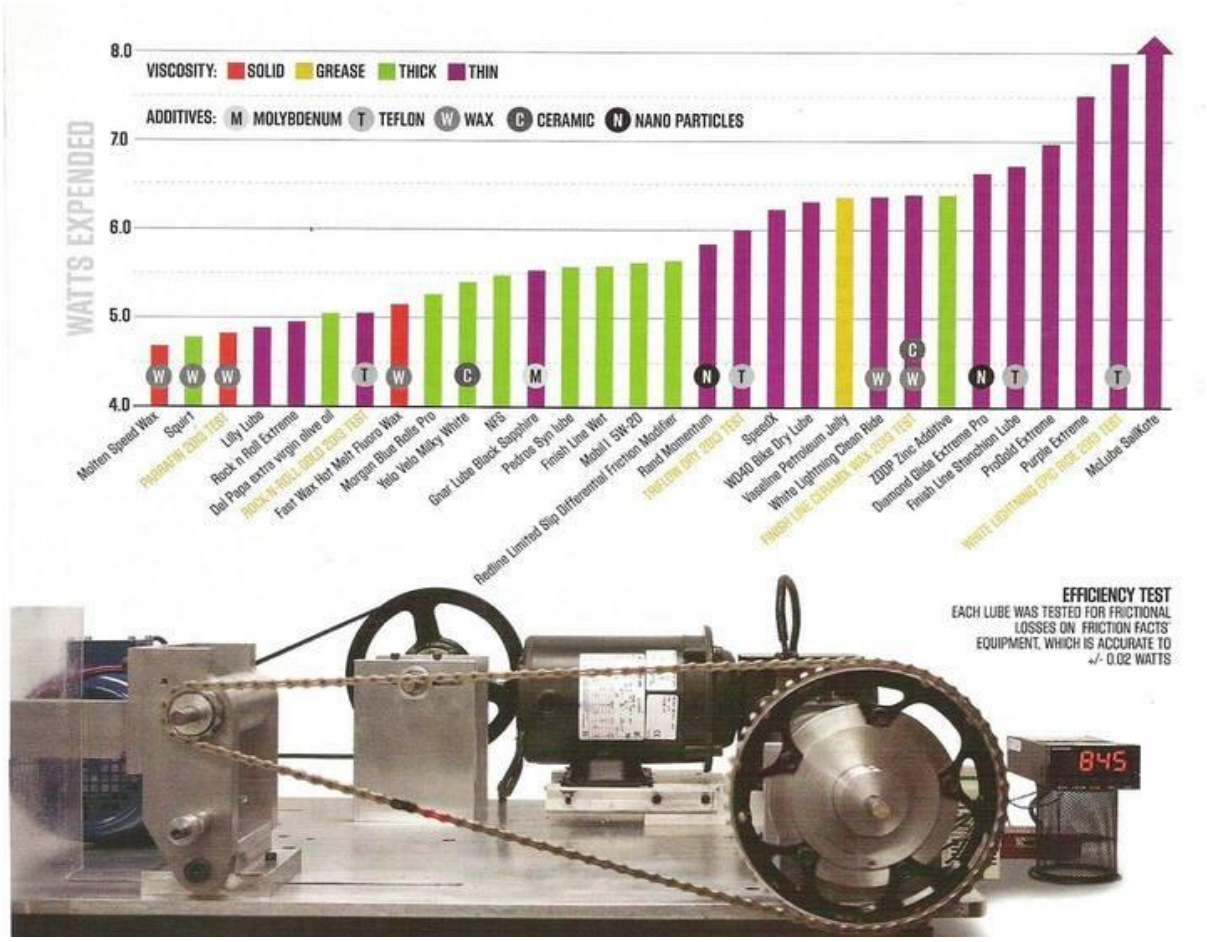
You can either be hit with both a lot of lost watts which are going into abrading through the metal components of your drive train, or you can save a stack of watts and greatly extend the lifespan of your drive train components. As 10,000 and then 20,000km are clocked up on your fine steed, the drive train running cost difference between a poor performing lubricant and high performing lubricant can be very large indeed.

If you are running ultegra or 105 or force or chorus – running a poor lubricant may come with annoying running costs but such that they probably won't break the bank. However if you are running the latest 12 speed drivetrains and a cassette that costs north of $700, and chain rings not too far behind – I simply cannot stress strongly enough that simply being on top of a good lubricant choice and good basic maintenance is something that really should be moved to a front of mind consideration. Worry about your ceramic bearings later – get on top of lube / chain first or risk having a bicycle with similar running costs to a Ferrari.

Just imagine you had to spend $1000+ replacing your bottom bracket and wheel bearings every 10,000km. That would hurt, and you would probably look for better options. So why accept a chain wearing out every 3000 to 6000km and notable wear rates to the rest of your drivetrain?

An irresistible case study on marketing vs reality.

Ok, so far in this little (not so little) compendium I have highlighted some concerns with a coloured rub on wax (Wend), Muc-Off lubes and testing, Pro Link Gold's metal conditioning, and a likely mid level lubricant apparently changing the face of race preparation. But just in case I hadn't quite nailed home the point on marketing claims vs data and reality, let us jump to the lubricant that tested with the highest friction losses in the original round 1 Friction Facts testing – White Lightning Epic Ride (this data on WLER is from when Friction Facts was completely independent and not owned by Ceramic Speed. On the graph below there is one lube that is worse which was tested after round 1 which I think is a motor oil…)



***Note White Lighting Epic Ride second highest losses at just under 8w, on a perfectly cleaned chain, in a clean lab.*

Now a peek at the marketing for WLER;

About White Lightning Epic Ride Semi-Dry Lube - 120mL

White Lightning Epic Ride Light Lube is a light bodied synthetic lubricant that provides extreme durability, smooth shifting and quiet riding in all riding conditions.

Epic Ride is an excellent all-conditions bicycle lubricant that satisfies the demands of road and off-road cyclists because it's uniquely formulated with non-petroleum based synthetic oils - this means it provides long haul durability without the excessive grime build-up common with conventional synthetic and non-synthetic wet-style lubricants.

Epic Ride's patented formula means it provides superior protection for chains and also works just as well on derailleurs and cables. Epic Ride will also smooth out stanchions and rejuvenate suspension seals and wipers.

Epic Ride is a “lube-and-go” product - no chain preparation or dry-time is required. Just apply and you’re off! Epic Ride is the lubricant choice for riders seeking the performance of a wet-style lubricant and the cleanliness of a dry-style lubricant.

Features

- No chain prep required before application
- Benefits of both dry and wet lube
- Works on derailleurs and cables
- Formulated with non-petroleum based synthetic oils

More About The Manufacturer White Lightning

In 1994, Paul Maples, a research chemist and cyclist invented White Lightning. Although White Lightning was developed to keep bicycle chains clean, users soon found that it worked on almost all bicycle parts. Since its introduction, WL has quickly gained broad acceptance.

Reader surveys for leading US cycling magazines* rate WL as the industry's most popular lubricant. Such a rapid growth in popularity is without precedent and speaks to the product's unique technology. Four U.S. Patents have been awarded to Paul Maples for his "Self-Cleaning Technology." With Paul's continued R&D leadership, White Lightning believes that its self-cleaning lubricants will ultimately change the way people maintain high-tech mechanical devices.

Especially that final paragraph, that is some pretty big claims to live up to indeed.

Ok to recap originally WLER came 55th out of 55 lubes tested from an efficiency persective, despite being a very light bodied lubricant and not a thick motor oil. In amongst round one testing there were also some pretty zany wives tale stuff tested including olive oil, vaseling and a mobil motor oil, all of which were way ahead. Not a good start.

But what about outside the lab where contamination is involved?

This is what ZFC test protocol assess, and things did not go well at all.

WLER absorbed contamination readily, it literally sucked up every granule, and held onto it. There was absolutely no self cleaning, with chain sounding and feeling horrible from the moment contamination was introduced. Wear rates reflected this with the chain hitting well above the 0.5% allowance mark at the point test was stopped. Higher performing drip lubricants such as Squirt, Smoove and NFS attained over double this amount of km's for a lower amount of chain wear, and it is worth noting these lubricants were subjected to much harsher contamination blocks as the test continues.

I managed to get the WLER chain friction tested in a full FTT lab at the end of ZFC testing and it was off the test scale at over 19w loss at 250w load – the FTT test had to be stopped early due to risk of damaging FTT machine.

I was also able to have the top performing lubricant tested at the end of ZFC testing round 1 (Molten Speed Wax). Molten Speed Wax was the only test chain to make it all the way through the 6 x 1000km blocks of the test including an extreme contamination block which throws a ridiculous amount of punishment at the chain – and the MSW treated chain was still just under the 0.5% wear allowance for the test.

So Molten Speed Wax at the end of a test that was designed with the expectation that no chain would make it to the end – recorded an FTT result of only 8.36w.

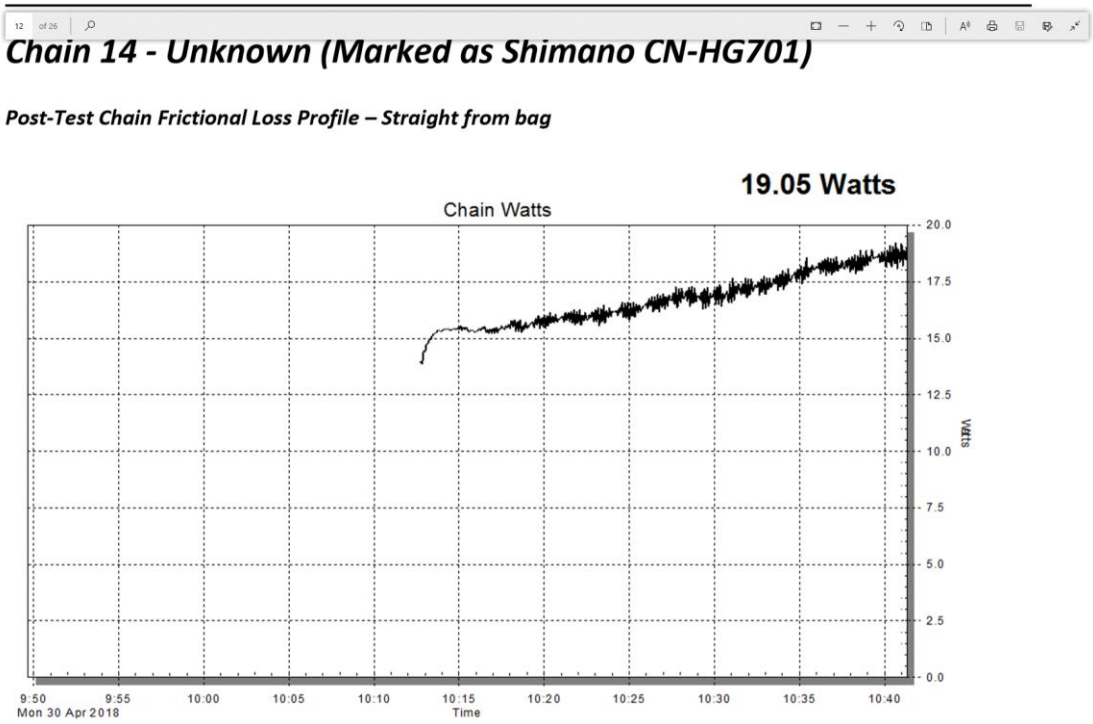
This is close to where WLER started on a perfectly prepped and clean chain in a clean lab!

Even allowing for some variances in chains that I used for my testing (shimano ultegra 11spd) vs the chains used in original FF testing (10spd Dura ace), we can ascertain some fairly accurate friction increases over time.

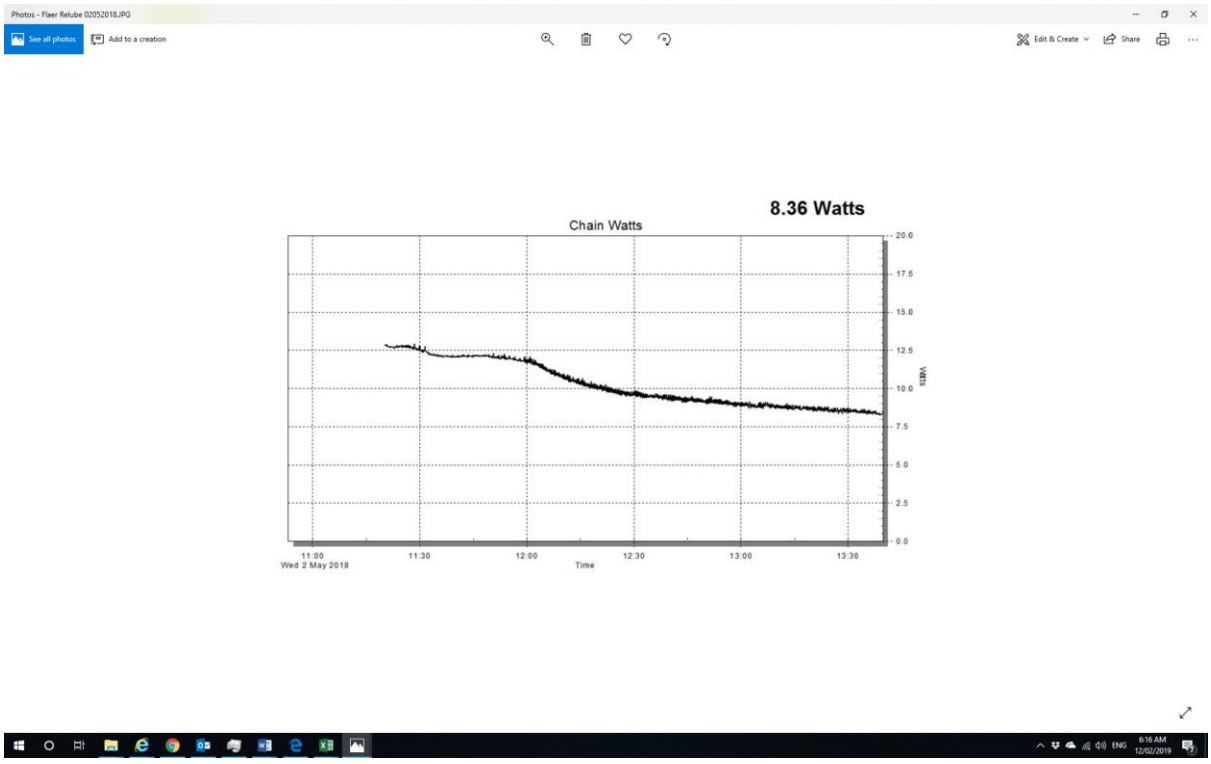
We can round Molten Speed Wax as increasing by around 3.8watts over a 6000km test that included a 1000km dry contamination block, a 1000km wet contamination block, and a 1000km extreme contamination block.

For WLER we can approximate an increase from just under 8w to over 19w – so an 11w+ increase, in just 2340km which included only the dry contamination block.

FTT test for WLER post ZFC testing;



FTT test for MSW post ZFC testing;



**You can see how losses keep dropping as wax breaks in post re wax – re waxing being the equivalent of a re-lube for MSW. WLER was also re lubed. Also note that for objectivity test facility was not provided with any details re chains / lubes.*

What would this mean in real world?

The ZFC testing protocol's strength is in its simplicity. Whilst almost all manufacturer testing is in a lab and lasts from 5 mins to maybe 13 to 14 hours, the ZFC testing goes for thousands of km's of controlled load and added contamination. Whilst no test can simulate real world riding (real world riding has so many variances in load and contamination that even real world riding struggles to simulate real world riding making real world testing results very ball park), the ZFC test protocol is able to assess many of the main marketing claims with regards to contamination resistance and ability to clear contamination by accurately tracking wear rates between clean and contamination blocks.

Being run over thousands of km's – the ZFC testing protocol gives an insight into how well the lubricant may stay near its lab test performance result. When we manage to get both FTT lab data and ZFC test data together we get a very good picture of how the lubricant is likely to perform in the real world as we having both its outright efficiency and its performance change with contamination.

In this case where I was also able to get the chains FTT tested post ZFC test, we can see an efficiency loss increase result that matches what the rate of chain wear rate increase showed us. In ZFC testing WLER chain wear rate rocketed up as soon as contamination was introduced, whereas MSW test chain wear rates barely changed until the extreme contamination block.

Remembering that chain friction increases almost linear to rider load (around 89% of linear), the losses experienced by a rider on WLER vs a rider on MSW would become very large indeed at loads above the standard 250w test load.

Post Zero Friction Cycling testing we are looking at 8.36w vs 19.05w at 250w load and therefore circa 14.9w vs 33.9w at 500w load. And that is with WLER be subjected to only around 1/3rd of the test km's vs the MSW chain, and around ¼ of the contamination exposure – including zero wet contamination exposure.

So ovreall that is quite some massive difference between the top and bottom performing lubes from the original Friction Facts testing. These lost watts would not only be a killer for how fast you are being propelled forwards for your input, but also the drive train running cost difference is absolutely enormous.

Frighteningly It is also worth noting that in the ZFC Round 1 testing that WLER did not even record the fastest wear rates! Wend Wax when applied as per original instructions as a rub on wax was the worst – who would have thought that rubbing a solid on the outside of your chain would equal no lubrication inside your chain where it is actually needed – so wend as a rub on wax tested with same wear rate as a chain with no lubricant. A perfect match between the laws of physics and ZFC test protocol, always handy.

Out of actual lubricants, Muc-off hydrodynamic and Nano lubes literally ate through chains like a sand blaster as soon as contamination was introduced. Scary, scary stuff for those on top tier group sets, especially considering the prevalence of hydrodynamic at LBS.

Muc Off / Wend are free to refute Friction Facts and ZFC testing by providing their own test data, full details of testing protocols etc. Oh and answer the questions in my emails to them during testing. (WLER I didn't bother writing too – my belief is that its performance results are simply a known and accepted fact in the industry since Friction Facts testing and I only tested it as part of bench mark data – but sales remain strong despite independent testing based on brand name and reputation, and that only a small % of cyclists read stuff like FF / ZFC testing).

However, Wend Wax and Muc-Off Nano were new product releases that really hit new heights with regards to marketing claims, so it sure would have been great if they answered the questions sent to them with regards to test results, their own testing and data etc. As soon as questions looked for something specific and not just marketing hyperbole, these questions were simply ignorned, and then my emails ignored. Muc-Off are also free to answer questions raised in my manufacturer testing fact check document – again I would love to receive answers to those questions, and I will update documents accordingly should I receive new information.

Online Product Reviews

Again another key reason why I commenced ZFC testing is that with the loss of Friction Facts and the absence of any real world simulation testing, there really has been very little to accurately guide consumers to a genuinely high performance lubricant vs poor lubricant.

Product testers for online publications I am sure for the most part do their level best to accurately review, however reviewing a chain lubricant certainly provides some challenges. Especially when the review is done after just a single ride or maybe a few rides, and is done basically off ride impression and feel.

When a tester receives a lubricant, they also receive the marketing information from the manufacturer. Many times the wonderful things the manufacturer has advised the lubricant will be performing just so happens to be what the reviewer feels is happening when they ride.

Again I can zing back to good old WLER as a case in point here. Knowing what we now know about WLER performance from very thorough and objective testing from 3 separate test facilities, here is what the first online review I found said re WLER, a rather glowing review from Road.CC ;

"Friction is notably absent on ultra sensitive nine/ten speed derailleur configurations, cantering up and down the cassette with remarkable finesse. Tenacious, we've ridden three hours in torrential rain, through waterlogged rural backwaters and partaken in moderate river crossings without the irksome telltale metal on metal abrasion when powering up the climbs"

So the review here is rather at odds vs objective testing done by Friction Facts, ZFC, and another separate FTT test lab post ZFC testing.

This is not criticising Road.CC or online publication testing in general – for many products online magazine reviews are outstanding and I use them a lot personally in my own cycling product selections – the majority of reviews for many product lines, especially from experienced tech writers, is often outstanding.

It is just when it comes to testing chain lubricants, this is extremely difficult to accurately do so based on feel and with the absence of objective data measuring. Without subjecting lubricants to a ride test protocol that involved same km's, load, contamination and accurate wear rate checking as a minimum, the review is going to be a lot of guesswork. When it comes to lubricants often the reviews are mostly just typing up of the marketing claims supplied to them. So these may not be of great guidance to you.

You will see the same issue with online forums – they are all over place. You can pick any lube you like and you will find someone who swears it's the most amazing lubricant ever and soon after another who swears it is the worst lubricant ever. There will also be no shortage of reviews on both forums and you tube with a vested interest behind it. For some lubricants with a bit of trawling you can get a good overall trend, but I wouldn't generally class the good ol interweb as reliable with lubricant reviewing as it is with many other product reviews – Again the reviews are simply almost always devoid of any actual tangible data, you will be striking it lucky to get accurate and unbiased information.

Scant few cyclists accurately record km's attained for their chain to an accurate wear mark – and that is even before we take into account the myriad of real world variables that will impact on one person's experience vs another. I have had customers contact me and say "X" lube is great, they got 10,000km out of their last chain. Then I measure chain and it is at over 1% wear vs recommended 0.5% replacement mark, they need a new cassette and chain rings etc. So that 10,000km longevity result doesn't really count for much. It was probably at recommended replacement mark at around 4 or 5000km, which is nothing very special.

And again, one person's perception or view as what feels good, looks clean etc vs another's varies enormously. I've seen chains that look like a coherent joining of sludge and the customer doesn't blink at it or ponder if there might be a better option, vs other customers who fastidiously clean chain after every ride or two and have tried about 10 lubricants in the last few years trying to find one they are truly happy with.

Summary;

- You cannot rely on manufacturer claims, brand, price or claimed tech to determine a high or low performing lubricant
- You generally cannot rely on online reviews to determine a high or low performing lubricant.
- You generally cannot rely on your own or fellow cyclists opinions to determine a high or low performing lubricant unless they can refer you to independent testing information to support.
- The efficiency loss and wear rate difference between high and low performing lubricants is enormous – it is well worth the time to get onto a high performing lubricant.
- The watts you save with a high performing lubricant vs a low performing lubricant that are now propelling you forwards faster for the same effort were previously going into abrading through your chain, cassette and chain rings.
- You need to rely on objective, independent testing, where the testing protocol is open and results stand up to robust scrutiny.
- Even if you never race, a good lubricant vs a poor lubricant will save you a small fortune in drive train running costs over the years.
- For those who like to maintain a clean running drive train, it is also worth considering how much is spent on cleaning products / solvents (as well as how you dispose of such) not to mention the amount of time spent cleaning vs riding. Again the difference in the level of cleaning maintenance required between lubricants to maintain high performance can be stark indeed.

There ARE lubricants that deliver well on their marketing claims, and deliver low efficiency losses, excellent contamination resistance, remain clean for impressive periods, and deliver excellent drivetrain component lifespan.

There are also lubricants that fit into the exact opposite category. Sadly it is the case that a number of the most powerfully, cleverly, and aggressively marketed products fall into the worst performing category.

And there is a big pile of "Meh" in between – with lubricants that are…. Fine. They are a lubricant, and they lubricate well enough. In a lab. But most will suffer from fairly rapid increase in efficiency losses vs lab test result once ridden and exposed to contamination. They won't turn into a bastard file like the worst performing lubricants, but without regular intervention they will certainly be a few branches below the top lubricants re losses and wear rates.

Understanding Lubricant types.

Chain lubricants face a unique challenge because the chain is operating completely exposed to the elements.

Manufacturers have tackled bringing an all conquering lubricant to market in a large variety of ways. We have lubes with added PTFE, or ceramic particles, or nano particles (all lubes contain nano particles by default by the way…), or wax based, or dry lubes, or synthetic oils, or metal "conditioning" lubes, or billions of laser crafted nano balls, and on and on and on.

For the purposes of this document, which will already be too long – I am going to keep the key learnings to a more simple break down. Wet lubes, Dry lubes, Wax Emulsion Lubes, Immersive waxing.

As a general rule, there are no free lunches when it comes to lubricating an exposed part. What is common is a key strength for a lubricant in one aspect can be a double edged sword in another aspect. Understanding a lubricants key strengths and potential cons will greatly assist you in being able to select the lubricant that is right for you.

Dry Drip Lubes

As a general rule – avoid. Their key "strength" is that they are cleaner. However to achieve this they are mostly carrier fluid which is designed to largely evaporate. This leaves the chain and drive train looking cleaner which is the appeal to many.

The double edged sword for dry lubes is that they typically contain an extremely low % of actual lubricant by volume (typically circa 10%). They tend to test with high friction losses as they provide little actual lubrication. Many do not go truly dry either, just less wet – so contamination is still gathered, and with very little lubrication to offset the gathered contamination.

And lubricant treatment lifespan is typically very short. They normally need to be re applied heavily every ride or every second ride leading to a very high product usage rate. This means that whilst the cost per bottle may look competitive, the total lube cost per 10,000km can be very high due to the usage rate.

Generally the most staggering wear rates I have seen in my time are with customers using dry lubes. I have seen chains worn from new to 1.2%+ wear (recommended replacement mark is (0.5%) within 3000 to 4000km. This results in cassette and chain rings suffering very high wear as well from running a too worn chain, and the customer ends up with bill shock. It is not an amazing experience for someone who saved hard to buy a new bike with top tier components, only to need to replace chain, cassette and chain rings 4000km later (thanks strava for accurate km's! ☺). Ouch. Sure – their drive train looked clean, but they have been riding around on a 20 watt-ish efficiency loss chain, and are now up for hundreds of $ to replace all drive train parts. Not cool.

Pro's – Chain and drive train look cleaner than most wet lubricants

Con's– Typically poor lubrication and high friction losses coupled with fast rate of parts wear. Short treatment lifespan. High product usage rate. All up they stereotypically deliver the highest drive train running costs per km along with the highest friction losses. With dry drip lubes the beauty is usually only skin deep.

*Exception – Ceramic Speed UFO Drip. This is an extremely low friction lubricant, and claims to be the only drip lube to go truly dry. It is marketed as a chain coating as leaves an actual solid coating behind, not just a less wet lubricant. Its treatment lifespan is still short, and its cost to use is very high due to product cost, but I do not believe its design brief was mass market daily lube, more as race day / dedicated race chain ultra low friction lubricant.

Wet Lubes

Under this banner are a huge amount of lubricants containing all sorts of tech from ptfe to ceramic particles to nano particles and on and on. Also many wet lubricants may be designed for specific conditions – ie wet or harsh conditions lube etc. A wet lube designed for good weather riding may be light bodied and with low efficiency losses when clean, whereas for harsher conditions the lubricant may be quite tenacious and viscous – typically meaning higher efficiency losses vs a light bodied lubricant, however it will not be washed off easily during an inclement conditions ride.

Wet lubes typically do not present with initial penetration issues which is common with wax emulsion lubricants – they will usually work their way onto chains pins quite quickly, and are also usually easier to perform a proper solvent flush clean to reset contamination vs wax emulsion lubes as many waxes do not respond readily to most solvents.

The double edged sword here is that every particle of airborne dust / contamination will stick on contact. Friction loss increases begin from kilometre zero. You can start with a perfectly clean chain and ride for an hour, indoors, on your ergo, and still have a black lubricant will be coming off your chain. Why?

Shine a bright torch into the air at night and see what floats through the beam. You will see A LOT of airborne particles float through. Any and all that contact your wet lube chain as you zoom through the air will stick and become a mixed in part of the lubricant. This airborne dust may be only mildly abrasive, and if the ratio of contamination to lubricant is low, the lubricant will remain relatively close to lab test performance for awhile, but sooner or later you will need to flush clean and re lube to re set contamination as it will continue to build.

However if you ride off road, or frequently along esplanades where a lot of sand will be picked up, things will degrade much more quickly.

But my lubricant “cleans as it lubes!” – it says so on the bottle! No, it does not. More on that soon.

Many cyclists will just keep adding lubricant and wiping chain. This has the chain looking clean on the outside again, but ride for 10 minutes and its black, again. Adding 5, or 10, or 15ml more lubricant and wiping chain is not cleaning as well as lubricating. It will improve

ratio of lubricant to contamination a bit for a short while, but it sure is a loose definition of cleaning. I cannot think of any other example in the world of where a similar level of change would be accepted as “cleaning”.

Your chain may look and feel how you expect a drip lube chain should look and feel, but if you have just been riding for a thousand km’s or more and just adding more lube and wiping, you do not have a chain that has being cleaned as its being lubricated. You will have a chain that has continued to increase its ratio of contamination to lubricant. The lubricant will be measurably more abrasive and higher friction losses after 3000km vs where it was at 1000km etc.

Efficiency loss increases can easily be 10w+ quite quickly for the lubricant if just kept lubing and wiping without resetting contamination levels with a full flush clean. Wet lubricants are typically a poor choice for off road conditions as all dirt and dust that makes contact is quickly integrated into the lubricant.

Wet ride lubricants do a brilliant job of staying on though harsh weather, but remember your chain gets hosed with gritty road water by your front tire. A lot will be absorbed. So whilst you can park your bike after a wet ride and not worry about chain rusting and grab it again for next ride and off you go, understand there is a penalty - you will have quite the grinding paste. If a lubricant stays on through the worst riding conditions – great – but it will have become a grinding paste by the end of the ride – full flush clean and reset or pay a penalty in friction and wear.

Pro’s – There are some very good wet drip lubes out there. They are easy to apply, and generally easy to clean and maintain. A good wet lube well maintained can deliver excellent performance, excellent parts longevity, and remain quite clean for an impressive period. Nix Frix Shun was the stand out on testing to date as so little of it is required to lubricate for very long intervals that it remained impressively clean and is easily maintained. It also tests in better end of the scale re outright efficiency. I was initially dubious of the marketing claims, but by the end of testing, I was on the blower to set up a dealer account.

Con’s –

- Airborne contamination sticks on contact.
- They do not clean as they lubricate.
- They cannot magically form a clean high strength film to protect chain metal from contamination.

- Claims of “metal conditioning” have not been upheld. Some claim to polish metal to a smooth shiny surface. Polishing metal takes friction. Lubricants claiming this attribute have tested by Friction Facts as being high friction (ie ProLink Gold). Always love it when logic and physics line up.
- Ceramic particles do not seem to help, and again intuitively adding ceramic particles does not make sense. Ceramic is very hard. Adding small very hard particles to your lubricant – how is that not just pre adding abrasive contamination? Why not just add some metal dust? Evidence so far suggests ceramic particles in lubricants acts as an abrasive agent increasing friction and wear. I am far from the first to raise this concern. However – ceramic lube sounds great from a marketing perspective and hence many big name brands have a ceramic lube in their line up along with a dry lube and wet ride lube etc.
- Any lube claiming things along the lines of filling in micro fissures with low friction particles etc - be wary. Maybe they are. But they are also gathering contamination as you ride and this contamination is scuffing in new micro fissures. It appears to be a zero sum game. We could be wrong – but again – intuitively and practically this approach does not make sense, and the evidence to support the effectiveness of such claims is simply not there that I know of. I am happy to be proved incorrect – manufacturers please send proof to back up claims.
- Regular full solvent flush cleans are required to reset contamination and efficiency loss performance. Depending on the lubricant and where you ride this may need to be done infrequently or it may be time consuming, expensive, and with a lot of dirty solvent going somewhere.

Wax Emulsion Lubes

A good wax emulsion lubricant typically has a blend of waxes or a particular wax base, using water as a carrier which evaporates leaving just the wax blend behind. A number claim they are “dry” drip lubes – but again they do not go truly dry, but often to a “semi dry” or “plastic” type state.

The best have proven to be low friction, very long lasting per treatment, and by setting to a somewhat “plastic” type state can be highly contamination resistant.

The double edged sword for these lubricants is that contamination is inevitable over time, even in good dry conditions, and the contamination that does penetrate is forcibly pressed into “plastic state” wax due to the huge pressures inside chain from rider load.

From there – it is effectively land locked in the lubricant. Adding more lubricant and wiping chain will shift practically zilcho contamination that has penetrated. Efficiency may

temporarily increase as you have improved the lubricant to contamination ratio, but overall there is little to no shifting of contamination that has penetrated – it is a land locked part of the semi solid lubricant.

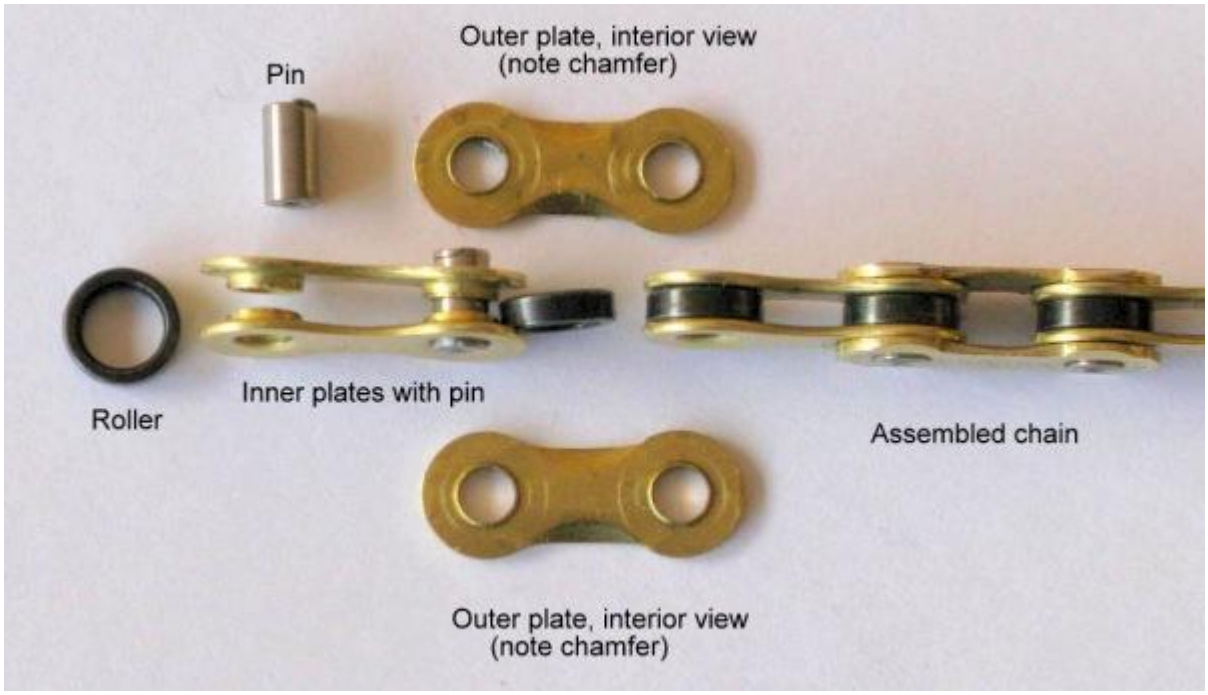
If one only ever rides in good weather, the time between needing to do a full solvent flush clean to reset contamination can be much longer vs wet lubes, and a single application can be very long lasting.

However, the other double edged sword is that proper application can be much more involved than what the manufacturer instructions will have you believe. The top wax emulsion lubricants tested to date have significant initial penetration issues to get to pin, resulting in initial high wear rates of pin and inner plate shoulders. This can be greatly negated by ensuring warm lube, warm chain, thoroughly work in whilst warm etc – but this is labour intensive process.

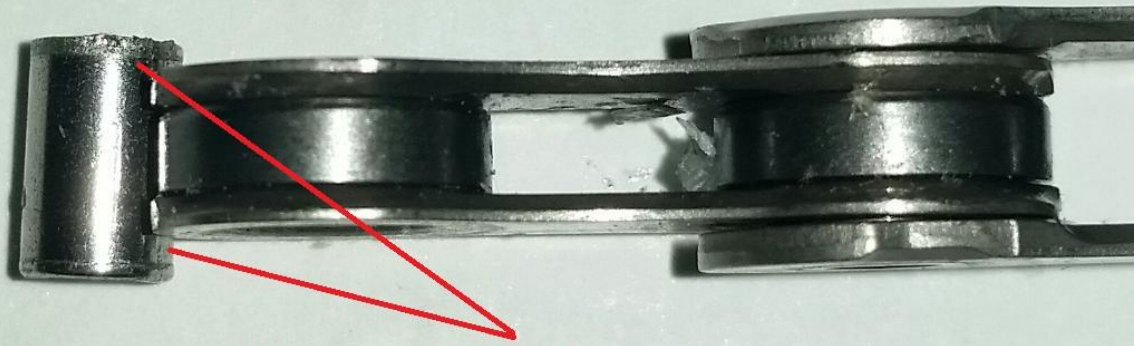
Other top wax emulsion lubricants have been tested as part of manufacturer lubricant development, and to date all have tested with around 20% wear rate for clean block 1, which is very high, and this has been reduced to as low as basically 0% when the wax lubricant has been immersively applied, so the evidence is quite stark and quite surprising re just how much difficulty wax emulsion lubes can have re initial penetration. The below pictures may help illustrate why penetration is more difficult than one may initially think. It can also help clarify just how tricky many of the lubricant claims are – just how does clean un contaminated lubricant penetrate past black contaminated lubricant to pin, and at same time contamination is moved out through this tiny gap so as not to be abrading away on pin.

But in short for wax emulsion lubricants, it has been tested multiple times for multiple top lubricants with applying as per manufacturer instructions vs immersively applying, and as per manufacturer instructions has in every case delivered between 19 to 21% wear in first 1000km perfectly clean running, which is a high rate of wear and therefore friction. The effort MUST be done re heating lube / chain / work in post full solvent clean to minimise these initial penetration issues.

*** This is where lubricants such as smoove / squirt will work much better in tandem with Molten Speed Wax prepared chains – you can add directly over top of MSW after approx. 100 to 200km of riding, and pins will still be protected with msw as Smoove / squirt takes its time to penetrate through. Many mtb riders prepping for a long event / multi stage event will take this approach.

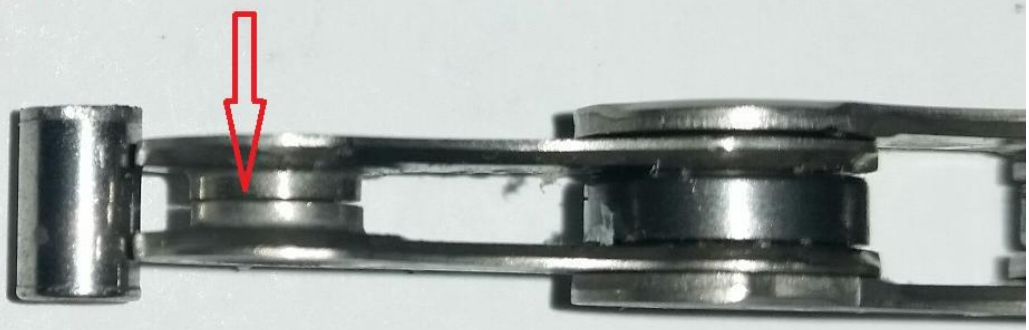


Pin is riveted to outer plates & does not move. Inner plate articulates around pin. When roller contacts teeth roller stops, and so inner plate also articulates inside roller.



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



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.

And as a third double edged sword (this sword has lots of edges!) wax emulsion lubricants tend to be a much harder clean when it does become time to clean. Over time they can get gunky, tacky, and most waxes do not readily respond (or respond at all) to many solvents, and the solvents they do respond too (ie xylene, wax and gum remover, Smoove prep) tend to be very expensive.

Lastly – whilst they can be as high or higher performing vs any drip lube in wet conditions – water provides the medium to transport contamination deep inside chain. This is inescapable. Once inside – it is forcibly pressed into lubricant etc. So unless one performs intervention to flush clean post wet ride then subsequent rides in the sun will still have similar friction and wear as if one was still riding in the wet.

This is the same for wet lubricants, and whilst a wet lubricant is less likely to perform as well for as long vs a top wax emulsion lubricant in poor conditions – it will be an easier solvent flush clean, and an easier re-application.

Pro's – Can be very high performing, contamination resistant, and long lasting per treatment. Generally a vastly better choice vs wet lubricants for off road riding and long extreme events.

Cons – Can also have significant initial penetration issues – recommend a much more involved process of warming lubricant and chain prior to application and thoroughly working in before thoroughly wiping off all excess. Are often a more time consuming, difficult and expensive clean vs wet lubricants when it does come time to clean – albeit depending on conditions cleaning maintenance may need to be far less frequent to maintain cleanliness and high performance due to high levels of dry contamination resistance. Proper intervention is highly recommended post any wet ride – full clean and re lube. This is the same for any drip lube, it is just a more involved and costly process with a wax emulsion lubricant.

*As such for non waxers – I recommend Smoove / Squirt for MTB /CX / Gravel riders due to dry contamination resistance, and also great for road use if rarely ride in wet and follow more detailed application instructions. However if only ride on road consider NFS as this has no initial penetration issues to faff around with negating and is a much easier clean for periodic maintenance.

Should better drip lubricants present during round 2 of lubricant testing this document will be updated. One is on the horizon already I believe ☺

Immersive Waxing

For 99% of riding and riders, immersive waxing is simply in a different league vs drip lubricants. There is a reason (actually, quite a few reasons....) why the first Optimised Race Chains to hit the market were an immersively waxed chain, and why this type of race chain continues to dominate at all levels with regards to the lowest friction choice possible.

Immersive waxing has the highest contamination resistance possible as the lubricant sets to a proper solid. The tiny amount of contamination that does penetrate in normal dry riding does not require a difficult clean – simply pop it back in the wax pot and turn pot on, swish around when melted – a re wax is your flush clean. There is so little contamination gathered in normal dry riding that no cleaning intervention between re waxing is necessary. No cleaning time, no solvents, just pop off and re wax.

Of course over time some contamination will build up in the wax in the pot, so it is recommended to change wax every approximately 20 to 30 re waxes. But even pretty hammered wax is still going to kick the butt of pretty much any drip lube unless you are fully flush cleaning your drip lube chain in between every re lube – which would be time consuming and very expensive.

For proper wet rides - again, despite solid wax being the most contamination resistant possible, water will transport contamination deep inside chain. However, here comes the difference between immersive waxing with a paraffin based wax vs wax emulsion lubricants. Solid paraffin is a shedding type wax, so abrasive particles will physically abrade wax off the chain. This means that immersive waxing will remain lower friction in harsh conditions for a period as a good amount of contamination is lost along with the shed wax - however it comes at the cost of treatment lifespan so the harsher the conditions, the more frequent one should re-wax.

Solid wax will remain amazingly resistant to friction increases due to harsh conditions until fairly suddenly one has next to no wax left on chain to be abraded off. At that point friction will rapidly increase to be similar to a chain that has no lubrication, as it will have little lubrication. This doesn't happen in a blink, especially deep inside chain on pins and inside of inner plate shoulders as that the solid lubricant is hard to get too and abrade off there, however it will not last like a non shedding wax emulsion lube – just remember the non shedding waxes will be integrating the contamination.

Solid waxes also do not respond readily to solvents, however will typically melt at around 60 degree's Celsius, so a couple of good flushes with just boiling water will deliver a remarkably good clean prior to popping back in wax pot.

Cheap wax like hardware store paraffin or candle wax still has a relatively high mineral oil content and so will be notably more gunky, become more contaminated more quickly, and not respond as well to just boiling water vs highly refinded (food grade) wax as the mineral oil content will not be cleaned by boiling water and will remain contaminated. Molten Speed Wax is very highly refined paraffin and so has almost no mineral oil content, and also has added PTFE and Moly to make even faster. Ceramic Speed UFO wax claims to be tweaked from original MSW / Friction Facts days but you cannot buy that wax and so I haven't been able to test it separately. If you bought a UFO chain then you can keep it as a super fast chain just be re waxing with MSW.

A key difference to understand with immersive waxing vs drip lubes is that;

- With drip lubes at any particular point in time you have a liquid that is "X" amount abrasive acting directly on chain metal causing "X" rate of wear.

- With immersive waxing, once the chain has been removed from pot and wax has set, all sliding surface parts of the chain are coated in a solid, slippery wax. Initially the chain metal is simply left out of the equation and wear rate is zero, then as the treatment wears thinner and some small amount of contamination is inevitable, friction and wear will slowly start to increase. It is a bit like a small piece of glass embedded in your tire. Run tire down and the glass gets a shot at your tube. As wax gets very thin, more airborne dust can penetrate, and more can get pressed into wax to have a shot at chain metal.

So there is marked difference in chain longevity depending on re-wax intervals. General best practice is circa 300km – testing has shown a distinct increase in friction and wear from around that mark. If one re waxes at around 300km, and changes wax in pot every approx. 20 to 30 re waxes (6000 to 9000km), then chain lifespans to 0.5% wear are typically circa 15,000km on good chains. Push re waxing to circa 500km, this drops to around 8000 to 10,000km. Re wax very frequently, and lifespans are pretty much un measurably long – people change bikes before they wear chains, the chain metal simply never really comes into play.

I have tested for 3000km re waxing every approx. 80 to 100km, and after 3000km chain wear was at 0.00.

Trying to achieve similar results with a drip lube would require enormous amounts of labour and solvent costs – it would need to be full flush and re set every ride, and even then attaining same results would be a stretch as simply popping chain back in a pot of wax and turning pot on.

For those that worry about keeping up with recommended re wax intervals, simply add another chain in rotation. You were always going to need another chain in approx. 5000km with drip lube, so pre buying next chain costs no more. Then you have one chain for Monday to Friday, one for weekend, re wax both at same time on rest day. Doing so for most riders will deliver around 30,000km of riding without having to worry about buying another chain, *cassette or chain rings. Rather hard to beat.

(*Exception is dura ace / XTR cassettes which are very soft, and even with wax will still wear. In fact waxing users find the very strange situation that after around 7 or 8000km when chain is still great, at maybe 40 or 50% of 0.5% wear allowance, chain will jump under power on some cogs as cassette has still worn. This does not happen with steel cassettes where you can rely on getting at least two chains to a cassette if replace at recommended 0.5 mark. This why even most pro teams on shimano run ultegra cassettes! DA cassettes - the larger cogs are made of an alloy that simply wears like butter, the 5 smallest cogs are steel and do not suffer this problem. I personally run red22 cassettes on my di2 bikes, as they are milled from billet steel and so are lighter, much longer wearing, and perfectly compatible).

The lubricant testing protocol of ZFC testing highlighted the key advantages with regards to contamination resistance, flush cleaning on re wax, and extremely low wear rates even in harsh conditions simulation. The top waxes like msw / ufo are probably the most tested and proven lubricants on the planet, unlike so many lubricants that claim much but have little or nothing to back such claims.

Listen to the below 4 mins of podcast from Josh Poertner (the man behind Silca's revival and marginal gains) – there is nothing faster.

https://pca.st/3TOB#t=2759

*** Note – where Josh refers to it being a pain in arse to do – that is in relation to fully race prepped chains. Fully optimised race chains do involve a lot of work – from break in, to many ultrasonic cleaning rounds, waxing with fresh wax, wax break in run, the race powdering runs. Day to day waxing is extremely easy, after initial clean of factory grease, it is simply pop chain off and re wax.*

The main limitation with immersive waxing is can be treatment lifespan, which for some events (like long harsh conditions event – ie 24hr mtb race) may fall short. In which case recommend Smoove or Squirt at the moment for those events, then simply switch back to waxing. But as stated at the beginning, for 99.9% of day in day out riding and racing, immersive waxing simply has a number of unassailable advantages.

Why is there a lot of negativity around immersive waxing?

Alas – the internet is full of more voodoo, myths and misconceptions regarding waxing, lubes and drive train cleaning than any other area of cycling I can think of. I cannot think of another topic in cycling that has so much incorrect information and thought trains out there on forums and in comment threads on articles.

To start with, for some, popping a chain on and off to re wax is just not for them. You drip a lube on a chain – that's just how it is. Removing chain to fully solvent clean and re lube = perfectly normal. Removing chain to put in a pot of wax = whoa! That's crazy talk man. I find this an interesting perspective ☺

Next is the vast majority of written information on forums and threads as well as you tube videos on waxing have incorrect information re initial clean and prep for waxing, as well as what to do between re waxing. Cleaning a chain for waxing is easy, but the devil is in the detail. It is two parts, part one is cleaning, part 2 is ensuring no film is left behind from what you used to clean. If you swish chain around in diesel, or petrol, or degreaser, give multiple baths until beautifully clean, and then wax – you will not have a good experience.

The fuel / degreaser etc will have left a heavy film behind on chain metal, wax will not have been able to adhere / bond to chain metal, and so a short few km's down the road one will have a horrible sounding and feeling chain as there is basically no lubricant on it. Then the person thinks oh wow, this waxing caper is rubbish. It is amazing just how many online reviewers have stuffed it up due to initial prep, and just how much incorrect information there is out there on something that is essentially very simple – one just needs to do the initial prep correctly (refer to mine or MSW instructions only).

So without sounding like a long advertisement for MSW, there is a reason why it is currently the number one recommended lubricant at ZFC. And it is here that it is important to remember what ZFC is about. Finding the genuine best in class products to stock. It is much easier and less time consuming to sell drip lubes vs immersive waxing, hence why I have put so much time and resources into finding the best drip lubes to stock for mass market. But to

date immersive waxing is ruling the roost by a big margin, will deliver big friction and drive train longevity benefits, as well as lowest maintenance and cleaning time – however despite all these advantages many have simply been mis informed by a mechanic or internet that waxing is crap. If it was crap, it wouldn't be the go to world record attempts and key stages at world tour level. It wouldn't deliver unbeatable drive train longevity etc etc.

There is a reason why the holy grail for many manufacturers is to deliver a lubricant that has the performance of immersive waxing but in the supposed convenience of a drip lube (remember with drip lubes you will always have more work at the back end re cleaning maintenance that offsets the time savings at the front end re just dripping something on).

There is also a reason why no small number of lubricant manufacturers try to discredit waxing as being immensely time consuming, dangerous etc etc – they want you to buy their product instead – our product is just as good, you can just drip it on and have the same performance, no danger etc etc. When a drip lube comes out that has the day in day out performance, parts longevity and cleanliness of immersive waxing, I will be stocking in a New York minute.

So as a wrap for immersive waxing (with proper waxes like MSW not candle or hardware store paraffin).

Pro's – Lowest friction – period. Stays lowest friction - period. Cleanest lubricant possible. No penetration issues. No double edged swords. Lowest parts wear rates / cheapest cost to run overall. Most independently tested and proven lubricant. No ongoing cleaning time / cost / solvent disposal.

Con's – Initial chain prep is simple but details are important to ensure no film left and proper wax adherence – follow instructions from ZFC only and it's a doddle – or simply get a pre waxed chain to start with and go straight to re waxing. Need to use master links to pop chain on and off – however re-useable master links are very cost effective. And of course if you are trying to keep a drip lube chain anywhere near its lab performance you really need to be frequently removing chain to fully flush clean anyway.

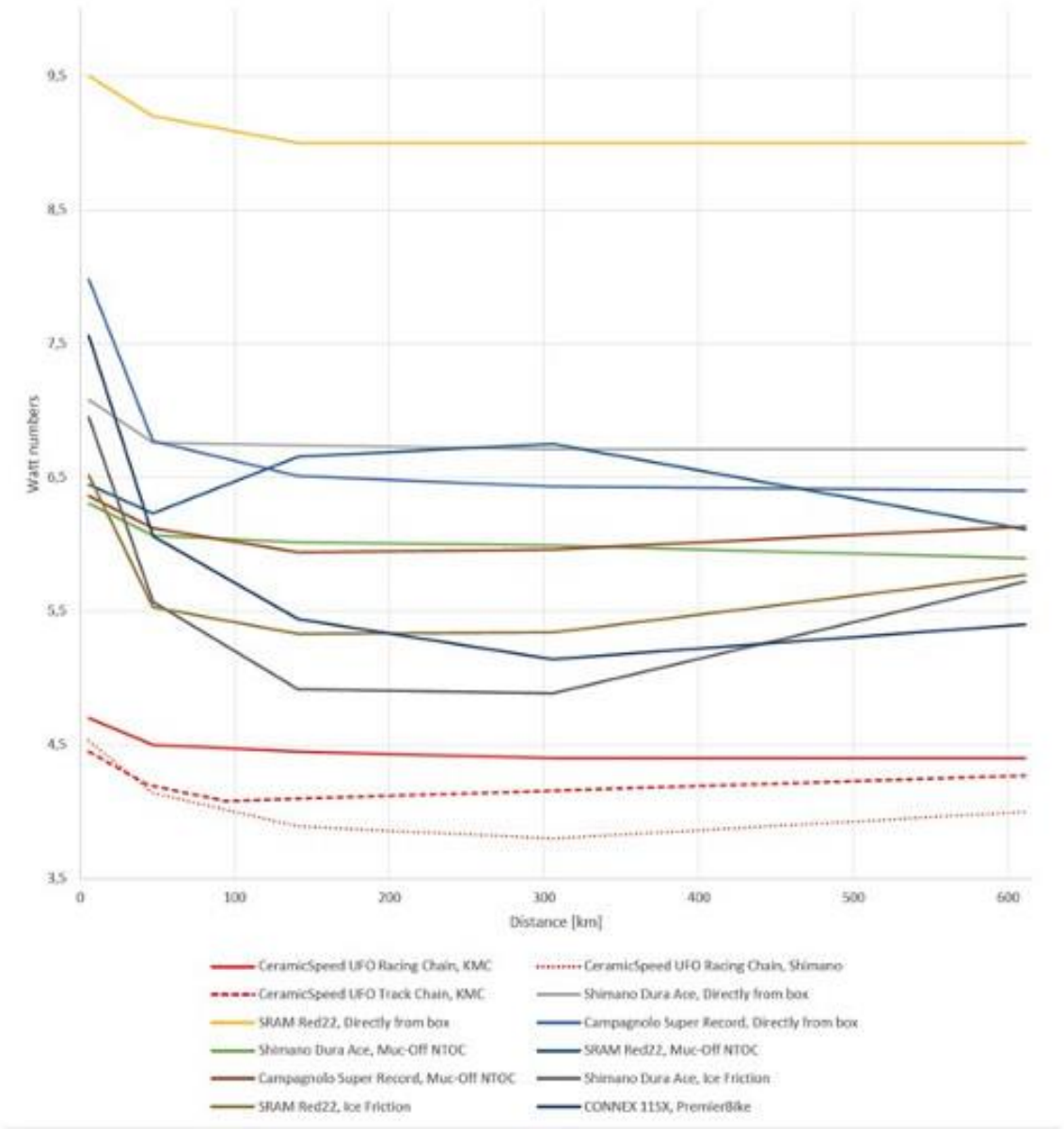
Miss-information / Fake News / Alternative Facts about immersive waxing…

- *Waxing is dangerous or a fire hazard*. Your car is dangerous or a fire hazard if you use it incorrectly, so is waxing. Paraffin is flammable, and can flash ignite if brought to too high a temperature. Hence why waxing over a hot plate, in the oven, in the microwave, on the BBQ etc is just not the way to go. You have poor temperature control, and in many cases an open heat source. All you need to do is use a slow

cooker on low, and you simply cannot go wrong. You just cannot possibly set your wax on fire in a slow cooker any more than you can set your water on fire by boiling it in the kettle. Waxing with a slow cooker is no more hazardous than dripping a lubricant on – it is that simple.

- *It is time consuming and complicated.* Popping a chain off with master links is very easy, as is putting it back on. If one has never done it before, it only takes a couple of times and they are off and running. Turning the switch on a slow cooker from the off position to low heat position is also not difficult. On balance for almost everyone immersive waxing saves time as there is no drive train cleaning maintenance.
- *You need to stand there with a thermometer and keep and eye on temperature as it cools and remove just before almost set to "lock in" as much wax as possible.* Pressures inside chain are in the thousands of PSI. Locking more wax inside will simply have more wax pressed out and flaking off in first few mins of riding, and then you will be at same place as if you simply swished chain around whilst wax at a good temp – anywhere between 70 and 100dg c, and hang to set. Re waxing is very quick and easy, and involves none of the above voodoo or hoohaa.

*** Note – immersive waxing and wax race chains refer to Molten Speed Wax or Ceramic Speed UFO chains only. Testing for other wax chains such as ICE Friction, Premier bike, and Wend wax are either poor or worse and do not recommend. The testing results obtained I have 100% faith in accuracy.



*Muc-Off Nano (race chain) Brown line averaging around 6w.

*Ice Friction chain lighter brown line averaging around 5.5w

* Premier Bike chain averaging around 5.3w but after 300km

All of above were initially very high.

FTT test of wend wax.

I tested the WEND WAX ON+OFF and it was quite surprising. So much so that we are now afraid it may have destroyed our test chain ☹

I rubbed the WEND on the chain (making sure to get it worked as much into the chain as possible) then applied the WAX OFF and rubbed it even further in.

Then the plan was 20 minutes, 1 hour, 2 hours, 3 hours, 4 hours and finally 6 hours (total) on the endurance machine. So after 20 minutes it would get 40 minutes to hit 1 hour and then measurements taken.

Here are the numbers (and for comparison 2 other wax lubes – One of them being a VERY famous/popular one and the other one is not on the market yet

Time (km)	WEND WAX ON+OFF	Wax Lube X	Wax Lube Y
20 min	6,49	4,60	4,81
1 hour	6,26	3,97	4,78
2 hours	6,78	3,81	4,79
3 hours	10,59	3,72	4,60
4 hours	-	3,94	4,60
6 hours	-	3,94	4,63

We had to alter our testing setup to measure above 8,81 and even then it's so high we suspect that it may have permanently damaged our main test chain. I have not seen any other lubricant hit the 8,81 max watts before – ever. I do not know what it did to our poor chain between hour 2 and 3 but that was a big surprise.

Anyway, it's terrible. Considering we managed to get that particular chain below 3 watts with a certain lube we are testing right after application (so "wet wax" so to speak) having it start above 6 watts is abysmal.

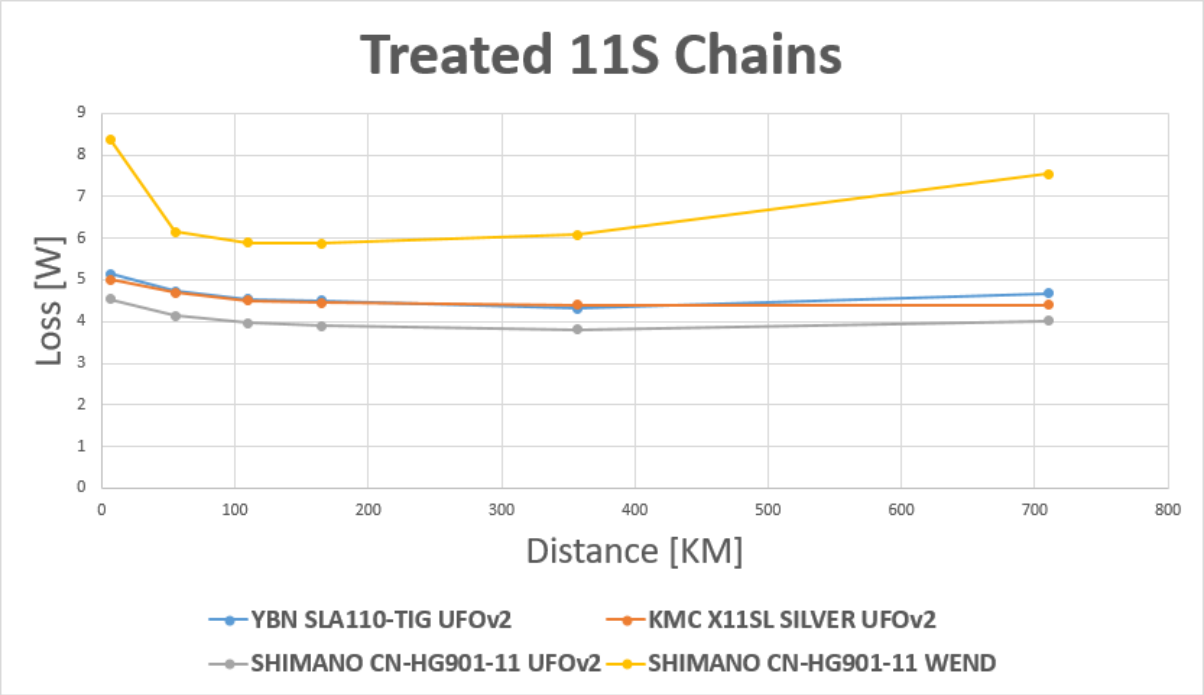
Data for Wend Factory Waxed Chain;

The data for the WEND chain was as follows:

7 min	8,37 w
1 hr	6,16 w
2 hrs	5,88 w
3 hrs	5,89 w
6.5 hrs	6,09 w
13 hrs	7,54 w

**Note – importer has advised this is not in line with data seen from wend. I was unsuccessful in obtaining test data from wend during ZFC test to prove marketing claims, and importer is also unable to provide data he has seen that contradicts above data from top test lab in the world in Denmark.

YBN chain recent test from same test lab.



Note approx. 0.5w difference between ybn and DA chain however in real world testing YBN coatings have wax adhering longer vs DA's coatings and much longer wear chain wear rates.

Other very important learnings / knowledge linked to above.

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 multiple rounds of ultrasonic cleaning, and the remaining will come out over time as you re-wax. As MSW is a shedding type wax, most will be lost on the road as you ride.

- 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 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.

A fully optimised race chain is a chain that has had specific load and length machine break in, many ultrasonic cleaning rounds until perfectly clean, waxed with fresh MSW, wax machine broken in, race powdered, powder run in, second race powder application. Done correctly, these are as fast a chain as one can make, but do take a lot of labour time. However once done initially, re optimising or keeping close to the above performance can be done at home much more easily than initial prep which really requires ultrasonics and machine to get highest level results. Refer to ultrasonic and race chain guide in instructions tab.

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 cyclists 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 toe 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).

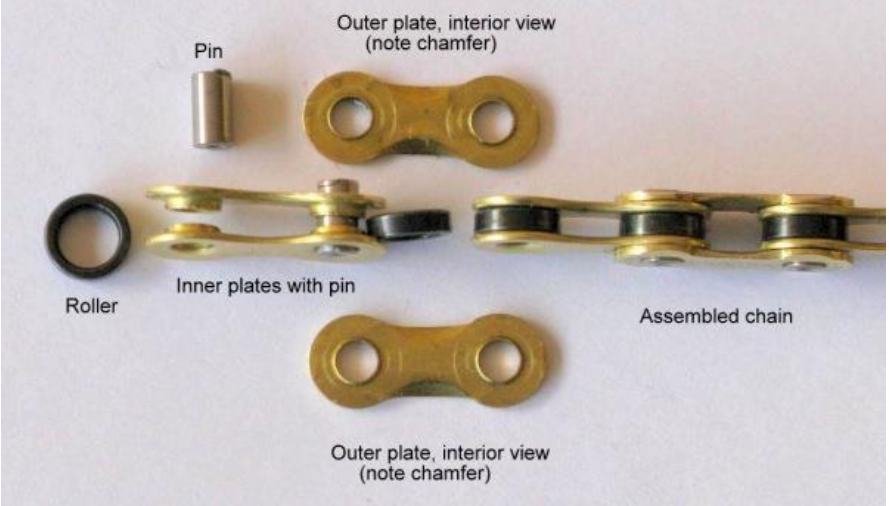
It is also worth noting that the wearing of the inside of the rollers and the outside of inner plate shoulders is still actual wear and it still contributes to a chains performance and damage to cassettes and chain rings. Some lubricants can be quite good at preventing contamination getting through tiny 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 three 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 p**l**atings 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 chains 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.

***** Note – alas there are a number of other factors that influence chain wear check results which make the above general advice only, if in doubt please check with ZFC. As a for instance;**

- **Shimano chains use slightly smaller rollers and with a looser fit on inner plate shoulders, and will on most checkers show around 20% "worn" when brand new**
- **Sram XX1 / XO1 chains typically have very tight tolerances onto inner plate shoulders and can show no wear for a long time. Contamination appears to have a very difficult time getting back out past roller and builds up. Have seen sram chains show 0 or only 20% wear on digital caliper and yet wear to cassette and rings has been notable.**

For most chains however, checking with good technique with a good checker will enable one to replace chains before they start rapidly wearing through expensive drive train components.

The most recommended cheap / simple drop in checker found to date is the Unior chain wear checker.

Alas – the graduations are out which is annoying, but as long as one is aware, it is an excellent tool because;

- It is laser cut and so each tool is exactly the same. With chain wear checkers the span they are measuring means that every 0.1mm is equivalent to approx. 20% wear. So longer tools, cast or more roughly cut tools, and tools that may suffer a tiny amount of bend or damage if dropped can easily be inaccurate from one tool to another or become inaccurate over time from dropping.
- The tool is short and very strong and so is highly resistant to above possible causes of damage

Note re unior;

0.2 = 0.0 – the 0.2 mark will go into almost all new chains (aside from some sram)

0.5 = 0.2 – time to think about moving race chain over to become training chain

0.75 = 0.5 – time to replace training chain

1.0 = 0.75 – lets hope you are not seeing this mark.

Drop in checkers area drop in checker, no force is to be used to get tool to fit between rollers aside from initially pressing back firmly against roller that hook part of tool slots onto. Other end with either hit roller if new condition or drop into a particular graduation mark.

Lastly – AXS Road!

The move to small rings and smaller cogs introduces great link articulation which is the opposite of what Oversize pulley wheels are all about. Whilst oversize pulley wheel systems will save approx. 2w by having chain articulate less around larger pulley wheel vs small 11t pulley wheel, moving to smaller rings and cogs is taking drive train friction in the wrong direction.

In my personal opinion, sram should have taken same move as campy 12spd and keep existing ring sizes and 11t cog.

A 48x10 gear combo gives same gear inches as 53x11, but at a 6w penalty!

Whilst the penalty may be lower in other gears vs top gear scenario, for any given gear inches one is always running a smaller rear cog and therefore more articulation and friction.

Also, sram top tier chains are hardy, but fast they are not. Testing on Sram AXS road fully optimised was 6.7w – which is very slow vs top race chains such as ybn / msw / DA at 4 to 4.5w.

However if on Axs road, those figures will only be worse the higher the friction the chain. As most savings or losses in drivetrain are from chain, then the lower friction the chain the lesser the penalty for smaller cogs / cross chaining etc. The worse performing the chain, then the bigger the penalty for the above.

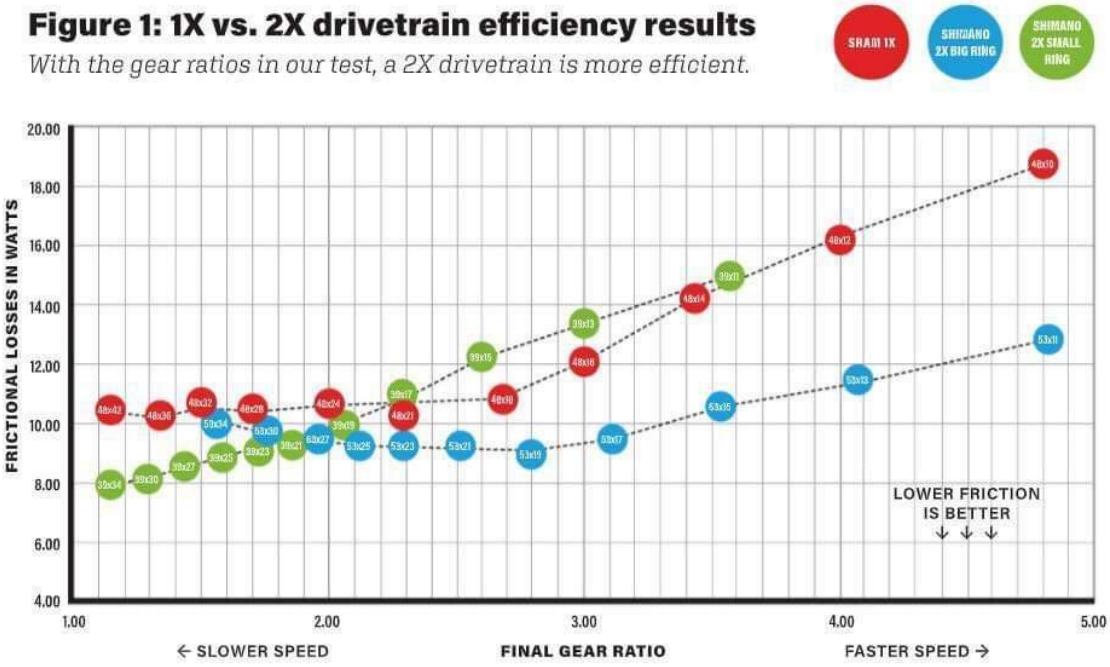
Running an average drip lube and poor maintenance and you can take those clean lab test results and double them, and maybe then some if on a really poor lube choice.

The attached is copy from article appearing in velonews in collaboration with friction facts / ceramic speed – credit for article and information to them

https://www.velonews.com/2019/05/bikes-and-tech/gear-issue-friction-differences-between-1x-and-2x-drivetrains_493185?fbclid=IwAR2A1cKzCccDcxBXCkQXID0V27-A6SV6B0WnY35LtOCUnuB93pJ4uc35vpM

Figure 1: 1X vs. 2X drivetrain efficiency results

With the gear ratios in our test, a 2X drivetrain is more efficient.



Previous FrictionFacts testing shows that narrow-wide teeth create no more friction when cross-chaining than do standard, uniform-thickness (i.e., 2X or 3X) chainring teeth, since every tooth on a narrow/widetooth chainring pulls the chain over the same amount; that is, it moves narrow and wide chain links laterally the same distance.

However, even when the chain is perfectly aligned in the 48 X 18-tooth, 53 X 19-tooth, and 39 X 25-tooth gears—hence no frictional losses due to cross-chaining—the 1X system consumes more power than the 2X system on either chainring. Why is that?

The major reason is higher articulation angles of the chain due to the chain going over a smaller cog on the 1X system; this forces the chain to bend more around the cog.

Tension on the upper span of a chain is inversely proportional to chainring size: The smaller the chainring, the higher the chain tension. That comes down to simple physics. Power output can be simplified to RPM X Torque. Torque is transferred from the chainring to the cogs by means of the chain tension. Since power output and cadence are constant in this test, RPM and Torque are identical in both larger and smaller chainrings. Thus, the chain tension (force) on a smaller chainring must be higher, as Torque is given by the equation Torque = Force X Radius, and the radius is smaller. Conversely, a larger chainring has a larger radius, and therefore the chain tension—and hence consequent friction—must be lower at the same RPM and power output.

This brings us to the relationship between frictional losses due to articulation and those due to gear ratios. Previous CeramicSpeed/FrictionFacts 2X drivetrain tests with a smaller rear cassette indicate there is a frictional minimum when the cog is aligned with the chainring (i.e., the chainline is parallel to the direction of the bicycle). With the larger, 11-34-tooth and 10-42-tooth rear cassettes of this test, however, the friction continues to drop beyond the point where the cog and chainring are aligned, albeit at a lower rate (a lower slope to the graph; see Figure 1), as the cog size continues to increase. In other words, with the smaller chainrings, the magnitude of drag reduction due to reduced angular articulation (with the larger cogs) exceeds the magnitude of the drag increase due to cross-chaining.

WHY THE VARIATION?

The chain creates the most friction.

The jockey-wheel (pulley) bearings create a small amount. Smith's previous research also indicates that the clutch in the SRAM 1X rear derailleur adds no friction.

Cross-chaining increases chain friction due to the increased lateral angle, increased chain tension, and increased link articulation (folding).

Cross-chaining robs power due to the plates scraping harder on each other. Smith's prior research reveals how cross-chaining and chain articulation angles and rate affect friction.

Higher chain tension increases drag by pulling harder on the pivot pins and by forcing the rollers harder against the teeth of the chainring and cog.

Chain articulation is essentially how many degrees the chain hinges at each pin to get around a chainring, cog, or pulley wheel, and how many times per second the chain goes through those articulations; power loss increases with increases in either one. Articulation rate increases with increasing chain speed. The larger the chainring at a given cadence, the higher the chain speed and the higher the articulation rate, and consequent frictional energy losses.