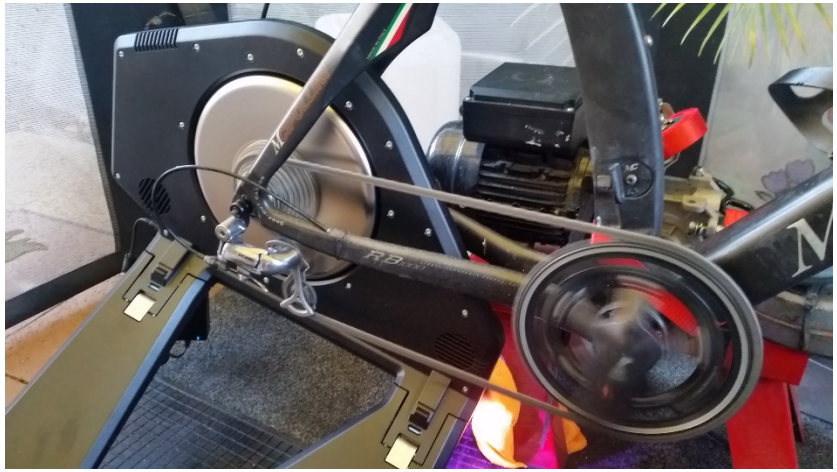
Zero Friction Cycling



Lubricant On Test : Allied Grax

Cost: $29 AUD + shipping from Allied in USA.

Size – 120ml

Photo :

Manufacturers Description on package;

IT JUST WORKS YOU JUST PEDAL.

Long days riding gravel can be as nasty as it gets. GRAX is formulated to shed moisture, mud, slop, and goo in extreme conditions and do it for a ridiculously long time. It exists to run fast, shave watts, and reduce drag over long distances for racers of all disciplines.

Directions on package;

STEP 1
CLEAN YOUR DRIVE TRAIN WITH GRAX OFF.

Apply GRAX OFF liberally to chain, cassette, chainrings, and derailleur pulleys

Scrub with nylon brush

Rinse with water

Repeat till it shines

Dry completely

STEP 2

APPLY GRAX.

Place applicator directly on chain

Pedal backwards

Liberally stream GRAX on entire length of chain

Shift through all gears

Let sit for one hour or more before riding

(if in a hurry, 10-15 minutes will work, but need to wipe off excess lube)

STEP 3
CLEAN YOUR DRIVE TRAIN WITH GRAX OFF.

GRAX lasts approximately 350 miles and can be re-applied three times without a deep clean of your drive train.

Under severe conditions (mud, rain, etc) GRAX lasts around 100 miles and requires a full ——————————cleaning before re-application.

Extra information from Manufacturer website

Video with colin Strickland demonstrating how to clean chain and apply grax.

“Science is your friend” – white paper on the performance testing of grax vs main competitors such as UFO drip, Squirt, Muc-off etc. This white paper covering testing has, in my opinion after deep investigation with Allied AND the 3rd party tribology company responsible, has a couple of EXTREME concerns re a deeply flawed test process and thus deeply flawed test results. Discussed in detail in main review.

Outright Efficiency rating: 4.56w loss from CS Denmark research lab – the only lab I can currently trust for outright efficiency results, I am awaiting a dependable independent lab to appear…

This compares to main competitors in this demographic;

UFO Drip v2 – 2.93w

AB Graphen lube – 3.1w

Smoove – 3.42w

Silca Super Secret – 3.82w

Squirt – 4.04w

Dry Fluid – 5.8w

Silca Hot Melt I do not have for public sale but I can say and call it very close to 3.5w. Mspeedwax new formula to be tested, expecting similar to hot melt.

Despite Grax ranking below a number of competitors here, note that 4.56w is STILL VERY GOOD.

When I started looking into chain efficiency in depth just a mere 8 years ago, Mspeedwax had won fastest lubricant on the market 2 years in a row at 4.6w loss. Things have definitely not sat still.

It is well worth considering this point. So, so, so often I am contacted re what about Rnr gold, what about tri flow, what about morgan blue & on & on. Nothing against those lubricants – I used to use RNR gold myself back in the day. Once upon a time it was a solid choice. Same as once upon a time a commodore 64 was an awesome personal computer and having a car phone was fudgeking amazing.

Bicycle chain lubrication has been moved forwards a lot, to sit still is to simply continually slide way way down the league table. Last test of Tri-Flow for track chains that is now over 4w+ slower vs fastest lubricants. What was great in 1990 is not going to be a contender in 2021.

So 4.56w would have been a winning result 10 years ago. It is still a solid result, not something I would consider slow at all for 99% of cyclists out riding / training & having fun, I wouldn't blink at running a 4 to 6w loss lubricant if very low wear in training, but I would definitely run something faster for races as there is an easy 1 to 1.5w per 250w load to be had with other options.

Viscosity: Very thick at 20dg room temp. Too thick in ZFC opinion which hindered penetration.

Test observations and review.

Ha here we go again – I am very very behind in detail reviews and REALLY need to work on making detail review more concise, alas almost every time there is a big topic to cover as part of the review!

And so it is the case with Allied Grax.

Before I get to Grax results, it is extremely important that I first cover the testing and claims made by Allied for Grax lubricant.

And that needs a mini preface in itself to ensure proper balance.

I really like Allied as a company. I have watched them over many years deliver some truly brilliant bikes to the market (not cheap, but brilliant) such as the Able, and now the Echo. Possibly two of the best gravel specific bikes ever made (in my opinion. I wish I owned one!).

It makes a lot of sense for Allied to want to bring hopefully the worlds best gravel specific lubricant to market to go with their world leading gravel bikes.

And understanding that bicycle chain lubricants these days really are high tech wizardry, it would be foolish to try to develop inhouse unless you have a nice bunch of PHD chemists on staff and a some very fancy testing equipment.

As such this was outsourced to a 3rd party tribology company (I will leave them un named here as who it was is not so important).

Again I absolutely agree with this process, it shows that Allied absolutely, without any doubt, were completely genuine in the efforts and investment to bring a genuinely brilliant product option to market, so I applaud Allied here as well.

Okay – from here – to save me typing "in my opinion" 100 times throughout the document, EVERYTHING WRITTEN BELOW from this point on is IN MY OPINION only based on information presented, and is NOT STATED AS PROVEN FACT.

Alas as best as I can tell from the discussions with Allied & Tribology company – one critical initial factor likely then led to the main points of concern to follow.

The Tribology company completing the testing for Grax was the same company as the one commissioned by Allied to develop Grax.

There is a pretty big conflict of interest here where the company you have hired to develop the worlds best gravel specific lubricant is then the same company providing you with the proof that they achieved what they were paid to do. Ideally of course one would want to have the lubricants performance independently assessed as well as any testing proof provided to you by the tribology company. The tribology company is going to obviously provide you proof they are nailing the product development brief they have taken your money to achieve. But what if the Tribology companies testing methods are flawed or skewed? Without an independent test body to review the testing and results, you are relying 100% on the company who you have paid a lot of money to re developing your lubricant then providing the proof they nailed it.

It is not quite the fox guarding the hen house, but it is definitely in that realm. It is, and was, a very big risk to take to have the same company develop the lubricant and provide the final proof to you that they succeeded in achieving the product brief assigned to them.

It seemed fairly apparent to me fairly quickly from the emails and long video call that;

- Allied lacked the expertise to spot some glaring concerns with the test protocol & results undertaken by the Tribology company, and placed 100% faith in the testing results for Grax by this company, and went to market with top performance claims with genuine belief in the market leading performance of Grax.

- The Tribology company did not have any prior experience in testing lubricants specifically in the use case of being ridden on a bicycle chain. They did not do any research on previous testing ie the journey and findings of Friction Facts.
- The Tribology company hence fell into some big traps for young players.

Major Flaws in the testing (again, in my opinion, but I am not alone, and…. There is a lot of physics and basic logic to back the major flaws allegation).

1) I will not bog down this document going through yet again Full Tension Testing & Full Load Testing (FTT & FLT) – for a deeper understanding head here - https://zerofrictioncycling.com.au/wp-content/uploads/2018/07/Fact-Check-Manufacturer-Lubricant-Testingv3.pdf

   It is a bit dated, but the core info on FTT & FLT testing remains absolutely unchanged.

   In short – Full Tension Testing is where the test machine has chain run on a chain ring, a cog, a weight pulls back to the cog to put tension (cycling load) into chain. This method is extremely accurate (assuming what is measuring losses is accurate) as there is very little "noise" in the system from other loss components – ie chain is not snaking around a set of pulleys.

   However- as proven by Friction Facts – with this test method the test runs must remain EXTREMELY SHORT.

   As the chain is under load (tension) on both top and bottom span of drivetrain, there is no slackening or resting period like there is on a bicycle. Many lubricants need this slackening time so that the lubricant layer can refresh and reset. If kept constantly under tension, the lubricant layer can be pressed out and depleted leaving metal on

metal. This is very true even for solid waxes and solid chain coating type lubricants, as the boundary layer actually melts a bit under load – the pressures are extreme inside a bicycle chain due to very small surface area of the load bearing parts – and then the layer re-sets through the bottom unloaded span of drivetrain.

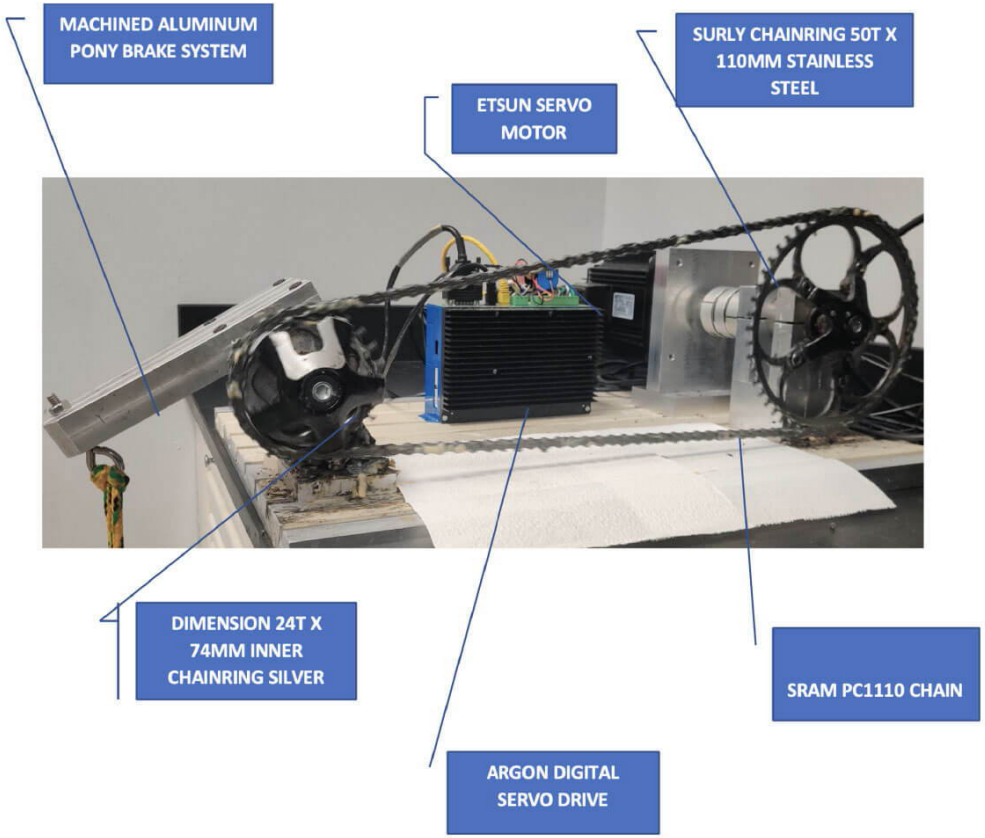
Hence accurate FTT testing, the test is typically only run for circa 30 seconds to 1 minute.

Again it has simply been proven ad infinitum – run a test for long blocks under FTT testing and at various points depending on lubricant, friction losses start to runaway, and then when chain is left to rest, they commence from where they were initially. So much incorrect test data is out there by test facilities running testing by way of long intervals on FTT test machine. NOT ALL lubricants are affected, and so in some cases it appears a base that is not affected may be selected for the mfg conducting the test, and so they get a great result of X hours whilst competitors attain terrible results (ie the main concern / allegation with Muc-Off's testing).

If I remember, I will attach at bottom of this review a more detailed explanation of why the slackening time is crucial, and it is obviously the reality of what occurs on a bicycle drivetrain and chain, and we need to test accurately re how a lubricant is performing in the actual use case of being ridden on a bicycle. Even single speed bikes – whilst the set up may look similar to an FTT machine set up, all the pedalling load is still only through the top span of the chain, the bottom span is under low enough load to allow reset of lubricant.

Hence the statement from their test white paper is incorrect;

"To achieve this, a bicycle chain tester was built to replicate a single-speed bicycle drivetrain, including chainrings, bottom brackets, and rear-hubs. A pony brake was added to allow the user to add/reduce weights, creating resistance. As shown in Figure 1, a high torque servo motor was used to power the system"



Having a simulated pedalling load distributed evenly across both the top and bottom span DOES NOT REPLICATE A SINGLE SPEED BICYCLE DRIVETRAIN. This method replicates the "Full Tension Test" method – a test method that is accurate IF RUN CORRECTLY.

We can see from the test results with UFO drip – again chain coating lubricants most absolutely must have the slackening period, that the text book FTT efficiency loss runaway result occurred by way of running the test for long periods (hours) under FTT test conditions. ***This was compounded by major test flaw number 2.***

2) When testing lubricants for outright efficiency, it is critical to ensure the lubricants are applied as per manufacturer instructions. If a lubricant needs at least an 8hr set time etc, this is critical. The results of the testing done by the tribology company are pretty…. Interesting all over, and part of this is because rather astoundingly they applied the lubricants, worked in for 2 minutes, and then commenced testing.

   This error is hard to fathom.

   Allied haven't asked their local barista to have a crack at lubricant testing, they have paid good money to suitably qualified people.

"The chains were adjusted onto the drivetrain system and a weight was hung from the pony brake of the bike chain tester to achieve the desired chain tension to accelerate wear/removal of the lubricant during testing. Each tested lubricant was then generously applied to the entire chain. The tester was initially run at a low speed for two minutes, allowing the lubricant to work into the chain rollers. The system was then run continuously for a period of 3 hrs. to allow measurement of energy losses beyond the functional life of each lubricant. These tests were repeated 3 times for each sample condition. **The testing parameters used were: (1) 70lb weight applied to the pony break, (2) 11.5 rpm shaft speed"**

Ok, so in my testing, if I did not follow manufacturers application instructions, including any required set time, and then obtained some terrible results for a lubricant on test, and then went to print without discussing / checking with

the manufacturer with regards to the results….. Quite rightly the manufacturer would have some darn good grounds to dispute my test results based on the fact that I did not follow application instructions, and would have every right to be pretty upset about things and question my professional ability.

If you are Tribology company testing bicycle lubricants, in a method you think will replicate what may happen when riding a bicycle, a pretty basic requirement would be to ensure any lubricants are applied as per that manufacturer's instructions, and extremely important on that front is any required set time – ESPECIALLY FOR CHAIN COATING TYPE LUBRICANTS.

Again I cannot fathom this basic error in the testing. It is what I would expect from a random person on you tube having their first dip into testing, not a Tribology company tasked with testing lubricants. To me a simple analogy re the scope of this error would be if they were tasked to assess an engine oils performance under high temperature, and conducted the testing at room temperature. It is just such a basic error.

I am feeling very sorry for Allied at this point, and not having warm feelings towards the Tribology company.

3) **Basic Logic mega fail.**

Alright, with any testing, if you attain results that are pretty much in the category of "Holy batman that is way, way, way outside expected values" – then that really should prompt one to thoroughly check everything. Including all aspects of the test protocol.

You do not need to be a PHD chemist, or a mechanical engineer, or even very mechanically minded to run the logic double check I am about to step you through.

We know that most lubricants when ridden outside are over time going to increase in efficiency losses. If you are riding in harsh conditions (ie dust, wet), then the main initial cause of this will be due to contamination of the lubricant. If you are riding in good conditions – such as dry road, then it can be that a lubricants treatment lifespan over time may be the main factor leading to increased losses as the hundreds of km's clock up – hence why we need to re-lubricate chains. If you are using only on an indoor ergo, increased losses due to contamination occur very slowly indeed.

So – have a bit of think, if you set off with a beautifully cleaned and lubricated chain and let's say it is 5w loss when you start riding, how many hundreds of km's do you think it will take to increase its losses by say 3w? that is a pretty decent jump (60%) from where we started. 500km? 300km? 1000km? Maybe you can't really pin down a very accurate number, but you know that a significant increase like say 3 to 5w is not going to happen in a snap. Even if it occurred in the 300km mark (which would be pretty terrible for dry road riding), if you average 30kmh, that is still 10 hours of riding.

To attain a very significant increase in losses, say circa 10 watts loss increase, taking chain from 5w to 15w loss, and in a very short time – one would obviously have to be riding in some pretty horrific conditions. Ie a 10w loss in say a 1 hour period, one would think man if I had to get that kind of efficiency loss increase in such a short time, I would have to be heading out for a full mudder cx event. You would be right in thinking this.

So when the Tribology company attained a circa 25w loss increase for UFO Drip, in just 1.4 hours, in clean lab test (notably cleaner than dry road riding), one should be thinking very obviously that such a result is an clear outlier to any logic of what could occur.

Seriously, I challenge anyone to properly apply a lubricant, and attain a 25w loss increase in just 1.4 hours. I have no idea what conditions one would have to ride in to attain such a result. It would be extremely difficult to attain such a massive increase, you would have to get pretty creative with the environment and conditions you were riding in – perhaps you were riding with drivetrain submerged in an industrial diamond slurry?

Hopefully it is jumping out at you as pretty darn obvious you are not going to attain a 25w loss increase in 1.4hours (say 45km of riding) – in dry road conditions.

How on earth does one attain such a test result, and think yep, good to go to print with that. We don't even need to check with the manufacturer of that lubricant re the result for any thoughts or input.

Again I am just at a complete loss for words here. I cannot believe Allied / Tribology company has not been sued by Ceramic Speed. They are a very gentle company. If they went to print with something like that for a company like absoluteBlack – after the founder recovered from an apoplectic fit a team of lawyers would have soon barnstormed Allied with a battering ram. And in that case, I would actually support them in such action for the first time. I am a bit surprised they haven't taken action against the results as they are as they still show AB graphene to be far worse than it is.

I think Allied have been EXTEMELY lucky not to be on the end of lot of messy legal action and being overtly discredited by Ceramic Speed. Again, I can say honestly, they are a very gentle company with such things, they just quietly let their own products performance do the talking vs taking apart other manufacturers claims. But still, Allied dodged a bullet big time, and honestly after the discussions with me re the above concerns, I am a tad bit shocked the test white paper is still up on website, it is oh so clearly completely flawed testing, and it makes them - in my opinion, look like a really bad company – something they are not.

My guess is that they simply spent a bomb on Grax development and testing, and so this test is a bit like sunk capital /stranded asset. They have put too much into it to let go of it, even though it is now doing them harm (ie think investment in recent coal power stations, legacy automakers investments in internal combustion engine). But, as painful as it may be, sometimes you need to let go and re-invest in where it is needed.

If I was Allied, I would pull that white paper off website immediately, and commence action with the Tribology company contracted for a big, big refund.

And as a bit of wrap on this in case you do read the white paper for a deep dive on the testing and results that are used to back Grax as the number one lube - there are a bunch of other concerns, in brief such as;

- Test was conducted at 11.5 rpm. I do not anyone who rides at 11.5 cadence. Lower cadence for a given power – higher tension load which emphasises one part of a lubricants performance but not others (viscous friction, stiction). Ie if one ran the test at 1000rpm (I don't know anyone who rides at that either) then for same power the

tension load would be extremely low, and huge emphasis placed on viscous friction and stiction. Something realistic would be a good idea to assess the lubricants performance in its actual use case.

- They use electrical losses for measurement vs torque sensors. This is vastly cheaper, and on the surface seems like a winner, ie volts x amps = power. If you have power supply able to measure power usage down to millivolts / milliamps, you can calculate a very accurate power figure. Subtract the difference between drive motor and braking motor and voila.

  Unfortunately, it is not that easy in practicality. Electric motors have significant losses (for this purpose) due to eddy currents. The efficiency of an electric motor is highly dependent on its operating temperature. As it heats up, its own efficiency decreases.

  If a lubricant is not performing as well, the drive motor will have to work harder. If it works harder, it will heat up and lose some efficiency. It may start small, but when we are looking at lubricant efficiency testing being AT MINIMUM 0.1w accuracy, small differences start to impact accuracy very quickly.

  If, however you get a lubricant performance issue by way of say running the test for long periods on an FTT machine, and not applying said lubricant correctly, thus soon likely having the chain running metal on metal, the drive motor is going to be working comparatively very hard vs a lubricant less affected, and the drive motors own efficiency loss increases will definitely start clouding the results.

It is extremely difficult to keep the motor's core temperature stable at an exact temperature from one test to another when the load it is needing to work is greater or lesser due to the above.

It is likely the typical feedback loop of motor working harder and warming up = increased losses in itself = needs to work harder to maintain same drive power output, working harder caused motor to further heat up causing increased losses, requiring it to work harder to maintain same drive output & so on. As it continues to need to work harder, the amount of volts or amps needs to increase, and so the greater power consumption needed to maintain the same driver power is attributed to the lubricants losses.

- A further logic check fail occurred when the sram factory grease was on par with many lubricants on test. Again it has been well established that sram factory grease is very very slow (circa 10w loss). It is postulated that SRAM factory grease attained such a comparatively great result vs many top lubricants as the factory grease was the one lubricant the Tribology company could not stuff up re the application of the lubricant.

Finally – I don't have all the answers with regards to understanding the test results produced for Allied, with a number of lubricants with known (according to ZFC.. me…) initial penetration issues testing seemingly not terribly with their method of just applying lubricant and running the test. I think it is likely that the extremely low cadence involved in the test, and therefore overall low simulated power, allowed some leeway re lubricant / penetration / performance – but without being able to pull apart the test in person, I have to make educated guesses from 10,000km away.

What I can tell you is that UFO drip absolutely needs its set time.

I can tell you that a 25w loss increase in just 1.4hours in a clean lab test is a positively bonkers result that should have warranted a full investigation of test and consultation with Ceramic Speed and that this was not done. This particular point I just have so much issue with. Even a pretty darn average lubricant if you head out on the road – in an hour and half if your chain losses increased by a watt, that would be a pretty bad result for that lubricant. How, how, how does one run with a 25w loss increase in a clean lab test in 1.4 hours. I think I need counselling after seeing this testing.

I can tell you that there is a mountain of evidence to warn against the pitfalls of long runs on an FTT test machine.

I can tell you there are many pitfalls to using electrical losses in an attempt to circumvent need for expensive torque sensors. It is very easy to get a bit of a runaway feedback loop of increasing motor temp & higher consumption.

All up, I can tell you that after reading the white paper for the testing done by the Tribology company for Allied, and seeing the test results, I had a host of concerns ranging pretty big to Fook ME!!

With luck, I hope that I have been able to sufficiently explain the concerns. Apologies again that a very topical issue railroads the detail review for a bit, but tackling the current horrific state of lubricant efficiency testing around the globe is a Priority 1 project at the moment. Current data conflicts so badly from one test lab to another we may as well be running a random number generator on google.

Handily, we have ZFC's extremely robust and proven wear rate correlation testing to either back or raise concerns on efficiency test results. Things simply cannot be low friction in the presence of rapid chain wear rates, and things cannot be very high efficiency loss (like 25w…) if for the same test period there is zero or near zero wear – Hence ZFC has become quite the back check / wicket keeper for manufacturer claims / test lab claims.

In my personal view, Allied – as a genuinely great little company themselves, and the intention for what they hoped with Grax was absolutely in the best interests of everyone, with a proper investment to bring a brilliant new product to market vs just re-labelling X existing lube under their brand name – If I was in charge of Allied, there is no way that white paper would be on my companies website, and proceedings would be under way for a rather enormous refund from the Tribology company.

Right - Back to the Lube review!

Right, due to severe time constraints and rather scary backlog of detail reviews to get done, and with big topical issues (like the above) tending to take up a fair whack of time, I am going to skip graphing up Grax block by block results and simply put the data commentary up. Some people have trouble reading graphs anyway and just prefer straight data 😊

ZFC TEST BLOCK 1 – Initial penetration issue check + dry road performance.

Wear % top 5 Lubricants tested = 1.1% *(Mspeedwax New Formula, Silca Hot Melt, Silca Synergetic, Ceramic Speed UFO Drip v2, Silca SS drip)*

Wear % top 5 DRIP Lubricants tested = 2.9% (Silca Synergetic, Ceramic Speed UFO Drip v2, Silca SS Drip, Revolubes, Rex Domestique).

Wear % - Allied Grax = 22.0%

Ok this is not a very good result, mostly it is caused due to significant penetration issues, an issue that plagues many wax emulsion lubricants,

A similar result was observed with Squirt and Smoove, both at 19.1%. And I can't state the wear rate due to NDA, but absoluteBlack Graphene demonstrated similar issues which is why the instructions are that when applying on a clean chain, it absolutely must be applied via immersive application.

In my opinion Squirt, Smoove, Grax – one should also follow that advice. I do have an advance application guide for Smoove, which helps, but does not at all negate the penetration issues of such lubricants.

Is this a problem for you?

Maybe. If you only ever ride in dry conditions (dry road, dry off-road) the high dry dust contamination resistance of a good wax emulsion lubricant mean that once you get past initial penetration issues, you do at least have fairly decent interval between needing to worry about doing a full flush clean of chain to reset contamination, and then have to faff about with negating penetration issues.

However – as I have been trying to drum out for a while now, if you ride in the wet, YOU MUST reset a chains contamination, no matter what you are running. To skimp on that is to run a lot of abrasive contamination next rides in the sun, and the accompanying friction and wear.

Water simply transports abrasive contamination deep into chain, it is pressed into lubricant, and effectively landlocked. It is not going anywhere unless you remove it. Lubricants that claim to clean as they lubricate – if you have the universes most loose definition of clean, then ok, sure. For any tangible level of cleaning to reduce friction and wear, you need to step in.

So how easily a lubricant can be cleaned and re lubed post wet rides needs to be of key consideration if you head out often in the wet. It is a different choice re lubricant that may last in harsh conditions for X event, vs what are you needing to do day in day in your riding.

An immersive wax, you can just pop off and re-wax (bonus points for boiling water flush rinse first). Lubricants like silca ss drip, ufo drip – the wax base also largely melts off with boiling water so a very easy flush rinse, dry, re lube as normal – those lubricants have no penetration issues.

Wax emulsion lubricants like Squirt / Smoove / Grax – they will not melt off with boiling water as a completely different wax base, you need to solvent flush clean = more expense, and you need to do a bit of work to negate penetration issues post clean – so such lubricant choices should be considered carefully if you head out into the wet.

You will not feel it when you ride. Such wax emulsion lubricants feel very smooth – a bit part of their popularity – and for the right demographic are overall an excellent choice. But the results are pretty clear – if you do not negate the penetration issues, you will pay for it with initial high wear until lubricant finally works its way to pin. Further detail on why this is difficult can be found here;

https://zerofrictioncycling.com.au/wp-content/uploads/2019/05/Key-Learnings-from-Lubricant-Testing-Round-1.pdf

(Scoll to page 29 to start).

Grax was extremely thick to apply at my workshops stable 20dg C. I often had to heat up the lube in bottle first to get it out of the nozzle. I was not surprised after applying the lubricant that significant penetration issues presented, and I followed all good normal processes to help enable penetration including liberal application, massaging in with gloved fingers, working in using both big ring big cog for maximum opening of chain parts as well as small ring small cog for maximum link articulation, and lubricant was worked in as thoroughly as feasibly possible without getting heat gun to warm chain and lubricant during the above which is a step beyond reasonable expectations vs application instructions.

I am not sure if there was an initial batching issue on early runs and that my bottles of grax were much thicker viscosity than they should have been, it is possible. However, even if a bit thinner as may be expected (I don't think I should have needed to heat bottle to get lubricant to be able to be expressed out of the nozzle without it being similar to applying

heavy grease on chain) – I believe it will be highly probably it would still return similar initial wear rates / penetration issues as per Squirt / Smoove.

As such, I recommend as a minimum following the advanced application guide on ZFC website for Smoove (this will be updated soon to cover all similar wax emulsion lubricants – the document needs a hard edit / update so pls forgive it if you read before I get a chance to do, tis on the list).

If I was me, I would absolutely apply via immersive post any proper chain clean, moving to advanced application method for re-applications. *(Get a 500ml screw top container from supermarket and small funnel, pour into container for immersive application, lid on, shake bejeezus out of in it, remove, thoroughly wipe excess, allow an overnight set if possible, or at least a few hours. Use funnel to decant back from screw top container into bottle).*

ZFC TEST BLOCK 2 – Dry Contamination.

Wear % top 5 Lubricants tested = 2.6% *(Mspeedwax New Formula, Silca Hot Melt, Silca Synergetic, Ceramic Speed UFO Drip v2, Silca SS drip)*

Wear % top 5 DRIP Lubricants tested = 7.5% (*Tru-Tension Tungsten Race, Ceramic Speed UFO drip v2, Silca super secret Drip, Tru-Tension Tungsten All Weather, Smoove. * Tru tension race was applied twice as often due to short treatment lifespan).

Wear % top 5 WET Lubricants tested = 24.4% - (Revolubes, Silca Synergtic, Nix Frix Shun, Rex Domestique, Rock N Roll Gold).

Wear % - Allied Grax = 18.3%

Okey dokey, not a terrible result – the average of ALL lubricants tested to date is 25.4% for this block, so it is above the average, but – for a gravel specific lubricant, I will be honest I was hoping for a lot more in this block.

With a wear rate that is over 4 to 5 times the wear rate of its key competitors Ceramic Speed ufo drip v2 – 3.4%, Silca SS drip – 4.6%) – that is a pretty big gap.

Yes those two lubricants in particular cost circa double a bottle of grax, how much are your drivetrain components worth? You will see in the total cost to run which factors in cost of lubricant, lubricant usage rate, as well as chain, chainring and cassette wear rate & cost – the vastly lower wear lubricants always dominate re lowest overall cost to run. There is not much point to save $20 on a bottle of lubricant if the wear rate of components cumulatively costing many hundreds of $$ is 4 or 5 times greater. Or 2 or 3 times. Or 1.5 times.

Personally I will very merrily pay $20 more to then shortly save some many hundreds of $$ in component wear.

The more expensive your drivetrain components, the more you need to take heed here. Running tiagra – ok, you won't take much of a comparative hit. Running AXS road or Ekar or Dura Ace or Campy Record – the cost to run difference will

be enough to cover new cycling kit, helmet, shoes, glasses etc. I much prefer spending my money on fun stuff vs easily avoidable drivetrain wear by simply making the best lubricant choices.

I have put up for reference in this section a comparison vs top Wet Lubricants as wet lubricants are a very big demographic even for Gravel riders / mtb riders – and again I keep stressing at EVERY opportunity I can, that running a wet lubricant in the world of dirt and dust is a complete miss match of product to use case. It is simply physics – every particle of dust will stick on contact to a wet lubricant. THEY DO NOT CLEAN AS THEY LUBRICATE no matter what some products claim. The dust becomes part of the lubricant, lubricant becomes a grinding paste.

It is not 1980 anymore, we have some absolutely AMAZING options that are extremely easy to use (refer top 5's) remain extremely clean for a very long time, and will save you a ton in running costs and maintenance time. Why oh why would one run a wet lubricant in the world of dirt and dust. If you want to walk across a beach and still have clean feet, are you going to put some oil on your feet first before crossing? No? Then don't put a wet lube on your chain and go ride in the dust unless you enjoy abrading through your drivetrain as fast as you can.

Right, sorry, I just have to hammer home the above as I am trying to save your drivetrain, your wallet, and there is so much BS marketing around some products performance for off road use when they are a wet lubricant. You have vastly more applicable options.

Back to Grax – I was not surprised by the block 1 result as that is common for that lubricant type, but I will admit I was hoping for much more in the block that is Grax's intended use case. It was very similar to Smoove / Squirt, not much better than top tested wet lubricants, way way off top tested products to date overall.

ZFC TEST BLOCK 3 – No contamination – demonstrate ability to clear contamination post block 2.

Wear % top 5 Lubricants tested = 0.6% *(Mspeedwax New Formula, Silca Hot Melt, Ceramic Speed UFO Drip v2, Silca SS drip, Smoove)*

Wear % top 5 DRIP Lubricants tested = 3.4% (Silca SS Drip, Ceramic Speed UFO drip v2, Smoove, *Tru-Tension Tungsten Race, Tru-Tension Tungsten all weather).

Wear % top 5 WET Lubricants tested = 18.2% - (Nix Frix Shun, Rex Domestique, Revolubes, Rock N Roll Gold, Silca Synergetic).

Wear % - Allied Grax = 18.9%

Okey dokey need to address one rather interesting data point here, and this Smoove jumping to a super low 2% in block 3 despite being 17.4% in block 2. The block 2 result for Smoove was still hindered by penetration issues that ran really long, it didn't actually really let contamination in, so finally once the lube penetrated, it delivered an extremely low wear result.

Overall re Grax for this block, we can see that the wear rate is very similar to block 2, so not demonstration much in the way of clearing contamination. It is very similar to Squirt which recorded 18%.

The top drip lubricants overall dropped their wear rates significant from an already low wear rate result in block 2, with SS drip dropping from 4.6% in block 2 to 0.0% in block 3, and UFO drip from 3.4% in block 2 to only 0.6% in block 3. So the two top competitors in this block are at basically back to 0% wear, whilst Grax is still over 18%, which is not a very close race.

Immersive waxing with top waxes (Hot melt and Mspeedwax) reset back to zero / near zero also as is the benefit of immersive waxing doing a brilliant contamination reset every time.

Grax was similar to the average of the top 5 wet lubricants in this block, so again, it is not a terrible product overall, it is a decent performing lubricant, but there is a pretty clear gap between Grax and a number of its key competitors.

ZFC TEST BLOCK 4 – Wet contamination block – demonstrate ability to resist friction increases in harsh wet conditions.

Wear % top 5 Lubricants tested = 20.8% *(Mspeedwax New Formula, Silca Hot Melt, Ceramic Speed UFO Drip v2, Silca Synergetic, Nix Frix Shun, Tru-tension Tungsten All weather)*

Wear % top 5 DRIP Lubricants tested = 31.2% (Silca Synergetic, Nix Frix Shun, Tru-Tension Tungsten All weather, Ceramic Speed UFO Drip v2, Silca SS drip).

Wear % top 5 WET Lubricants tested = 45.3% - (Silca Synergetic, Nix Frix Shun, Rex Domestique, Revolubes, Rock N Roll Gold)

Wear % - Allied Grax = 42.0%

Not a bad result overall, but also again nothing to write home about. It compares favourably vs many wet lubricants but note the top two (silca synergetic and nix frix shun) averaged 28% so that's a big jump better vs Grax.

Versus the top 5 drip lubes tested overall it is a solid 10% higher, and when bringing in the average including the top 2 immersive waxes, it is then double the top 5 lubricants overall, and around 5x wear rate of mspeedwax and silca hot melt.

If you had a decent wet event and you prepped your chain very well with grax for the event (immersive application, overnight set), it will be solid choice. It was just ahead of both Smoove & Squirt in this block (45.1 & 48.9% respectively, and they are really the two most similar lubricants re type). However, there are clearly better options available.

CUMULATIVE WEAR BY END OF BLOCK 4

Grax had exceeded its total wear allowance for main test by the end of block 4, at **101.2%** of the 0.5% net wear allowance.

Compared to top 5 lubricants tested to date – they have an average wear rate of only 35.1% by the end of Block 4, with the top 2 (Mspeedwax and Silca Hot melt) at an extremely impressive 12.7% of wear allowance used. The top 5 at the time of this review are Mspeedwax, Silca hot melt, Ceramic Speed UFO drip v2, Silca SS drip, Tru Tension Tungsten All weather.

Grax Compares Similarly to the top 5 wet lubricants tested to date which average 93.2%.

The most similar lubricants to Grax – Smoove was at 87.3% by end of block 4, and Squirt at 109.4% - so Grax is settling a little bit aft of midway between them.

Grax was not tested in Clean block 5, nor Extreme Contamination Block 6 as it had exceeded wear rate allowance. An extrapolated result is therefore used for Extreme contamination block performance – a wear rate of double that of its block 4 result is used as an approximation.

Full wear rate data for all lubricants tested to date is available on the lubricant test page if you wish to check the data table.

Single Application Longevity Test Results

Again apologies this data table is still small as a much improved test protocol was introduced in 2021 and I need to re test many lubricants.

Dry Road Conditions;

Lubricant	Real world KM's Adjusted - Jump Point	Real World Km's to Wear allowance
Rex Black Diamond	1,867	1867
Revolubes	1,139	1139
Rex Black Diamond + Race Day Spray	1,138	1138
AB Graphene Lube	1,000	1085
Rex Domestique	1,067	1067
Mspeedwax New Formula	600	1021
Silca Synergetic	778	778
Allied Grax	696	696
Silca Hot Melt	433	531
UFO Drip V2	300	394
AB Graphene Wax	100	140

On the slowly building table so far we can see that Grax is not quite taking it to the top outright longevity per treatment lubricants, but the table is currently a bit of tough league table at the moment being mostly populated with many of the top lubricants tested to date. The result overall for Grax is quite decent, I would expect similar for Squirt, Smoove I think will have a little more legs.

Note for Single Application Longevity testing, the lubricant is applied via immersive, and after 1000km (same length as Clean block 1), Wear rate was 9.54%, under half the block 1 result – during which has Grax is applied 3 times as per mfg instructions – this again supports the high initial penetration concerns.

Dry Contamination Conditions (Dry gravel / mtb)

Lubricant	Real world KM's Adjusted - Jump Point	Real World Km's to Wear allowance
Rex Black Diamond + RDS	880	1023
Mspeedwax New Formula	550	616
Revolubes	367	529
Allied Grax	421	517
Rex Black Diamond	489	489
AB Graphene Lube	483	483
Rex Domestique	385	385
Ufo Drip v2	150	360
Silca Hot Melt	300	343
Silca Synergetic	167	230
AB Graphene Wax	100	140

Grax Shot up the league table here a bit with a strong result. Again its wear % at end of 1000km on a single application applied immersive was notably lower than the wear rate it achieve during block 2 – dry contamination block, which has multiple re-lubrication points, showing that an immersively prepped Grax chain is a different level indeed vs one where it is applied as per manufacturer instructions.

Wet Contamination Conditions (Harsh wet conditions).

Lubricant	Real world KM's Adjusted - Jump Point	Real World Km's to Wear allowance
AB Graphene Lube	200	270
Silca Synergetic	167	230
Silca Hot Melt	100	212
Mspeedwax New Formula	100	196
Rex Black Diamond	100	179
Rex Black Diamond + RDS	100	175
Allied Grax	100	150
Rex Domestique	100	143
Ufo Drip v2	50	119
AB Graphene Wax	66	115

A bit of drop down league table in wet vs top options, but again overall it is a respectable a result with most lubricants on the table (exception being AB graphene wax) being most of the top lubricants tested to date.

COST TO RUN PER 10,000km

Alrighty this data below should be for the majority of cyclists what really guides home what may be the best lubricant options to try for your cycling. The cost to run Data per 10,000km of cycling factors in;

Cost & usage amount of lubricant. Some lubricants may be cheap but you use a lot of the product. Some lubricants are expensive but you use very little per re-lube & each application lasts a long time etc.

Based on the chains wear rate during test, cassette & Chain ring wear rates can then be factored (assuming one replaced chain by 0.5% - most groupsets you will be able to attain 2 chains per cassette and 6 chains per chain ring. The cost of those components based on the above is able to be calculated at 2021 Online store market prices for those components.

Different scenarios & groupsets are factored so you can more easily ascertain which lubricant may suit your cycling best.

Ie some lubricants may do very well in dry contamination, but have comparatively high wear in wet contamination.

The higher tier / more expensive your groupset, the more attention you need to pay to a lubricants wear rate. The cost of the lubricant itself is almost inconsequential **IF it delivers extremely low wear.** However a cheap lubricant with still decent performance may be all you need if you are running Tiagra / 105 / sram apex / NX / GX etc.

A quick tip here though is that whilst more budget level groupsets can have good lifespan with cassettes & chainrings, budget chains typically wear MUCH, MUCH faster than top tier chains. Without any specific wear resistant treatments (like

chrome plating on pins / rollers) – a cheap chain even on a respectable lubricant can still rip its way to 0.5% many times faster than a high level chain. Ie a sram GX chain will reach 0.5% extremely quickly even on very good lubricants, whereas srams x01 is one of the longest lasting chains in the world.

In short – if there is one part you should not buy cheap, it is your hardest working component by absolute miles that is completely exposed to all contamination. Swap out the budget chain from the go for a top tier / second to top tier chain. I save any budget chains I get for full wet days so my good chain is saved from some wet abrasive work, and depending on the chain / riding I would bin that cheap chain after circa 3 to 5 solid wet rides etc.

The data below is just the summary data, full data can be found on ZFC website / Lubricant test page – this breaks down the cost to run for each situation to lubricant cost, chains used & cost, cassettes & chainrings used and cost.

I can only model a limited number, but you can apply the applicable table to your riding, and if your groupset is more expensive than the one modelled (ie you are running axs road on your gravel bike vs GRX 810, or sram eagle xx1) then you understand that if you components are more expensive, so will your cost to run as they wear.

You will see the cost to run differences per 10,000km of cycling are notable indeed. For many cyclists vs what you are using now, moving to a proven top lubricant – the savings per 10,000km could easily cover the cost of buying that new pair of sunglasses, helmet, kit, shoes – all of it, or you can blow that hard earned cash on burning through drivetrain components.

Burning through drivetrain components is also very wasteful from a resource perspective. Some cassettes and chain rings use some high end metals which undergo a number of treatments & machining making them quite energy intensive to produce, then they need to be packaged and shipped all around the world. When you can often easily at least double to triple your component lifespan simply by a better lubricant choice…. Well, that is a huge driver behind why I spend a frankly nuts amount of time running the worlds most exhaustive testing, follow up data work post test, and COMPLETE detail reviews.

Cost to run pre-amble done – lets get to it!

Dry Road conditions- Ultegra 11spd groupset.

Ultegra 11spd Components	Total Cost to run Per 10,000km
Mspeedwax New Formula	$ 101.60
Revolubes	$ 101.70
Silca Hot Melt	$ 142.90
Ceramic Speed UFO Drip New Formula	$ 237.73
Silca Synergetic	$ 284.97
Silca SS Drip	$ 290.92
Tru Tension Tungsten All Weather (I.P)	$ 305.30
Smoove (I.P)	$ 342.10

Rex Domestique	$ 358.40
Squirt - (I.P)	$ 369.45
Nix Frix Shun	$ 378.15
Allied Grax	$ 379.70
Rock N Roll Gold	$ 471.90
AB Graphene Wax	$ 552.90
Wend wax 2	$ 574.00
Cycle Star Gold	$ 602.00
Tru Tension Tungsten Race (D.A)	$ 630.84
White Lightning Epic Ride	$ 735.40
Muc Off Hydro Dynamic	$ 799.05
Muc Off Ludicrous AF	$ 898.60
Muc Off Nano Lube	$ 1,222.70
Ab Graphene lube - TEST RESULTS LOCKED BY NDA	

Dry Road conditions- Dura Ace groupset.

Dura Ace 11spd Components	Total Cost Per 10,000km
Molten Speed Wax New Formula	$ 240.90
Revolubes	$ 241.00
Silca Hot Melt	$ 275.90
Ceramic Speed UFO Drip New Formula	$ 626.43
Silca SS Drip	$ 810.92
Tru Tension Tungsten All Weather (I.P)	$ 902.00
Silca Synergetic	$ 925.46
Smoove (I.P)	$ 1,134.20
Rex Domestique	$ 1,161.00
Tru Tension Tungsten Race (D.A)	$ 1,191.84
Squirt - (I.P)	$ 1,236.75
Allied Grax (I.P)	$ 1,247.00
Nix Frix Shun	$ 1,278.85

Rock N Roll Gold	$ 1,477.10
AB Graphene Wax	$ 1,655.90
Wend wax 2	$ 1,738.00
Cycle Star Gold	$ 1,766.00
White Lightning Epic Ride	$ 2,162.00
Muc Off Ludicrous AF	$ 2,391.00
Muc Off Hydro Dynamic	$ 2,519.75
Muc Off Nano Lube	$ 3,754.00
Ab Graphene lube - TEST RESULTS LOCKED BY NDA	

Dry Gravel riding – GRX 810 Groupset (reference for dry mtb riding as well just factor your groupset component cost vs GRX 810).

GRX 810 Components - Dry gravel / Mtb / Cx	Total Cost Per 10,000km
Mspeedwax New Formula	$ 149.85
Silca SS Drip	$ 180.47
Ceramic Speed UFO Drip New Formula	$ 226.65
Silca Hot Melt	$ 275.85
Tru Tension Tungsten All Weather	$ 289.75
Smoove	$ 362.50
Silca Synergetic	$ 366.72
Allied Grax	$ 377.25
Molten Speed Wax	$ 390.08
Squirt	$ 443.25
Nix Frix Shun	$ 541.05
Rock N Roll Gold	$ 635.82
Tru Tension Tungsten Race (D.A)	$ 642.28

Cycle Star Gold	$ 758.50
Wend wax 2	$ 792.75
Rex Domestique	$ 797.50
Revolubes	$ 812.50
White Lightning Epic Ride	$ 1,202.25
AB Graphene Wax	$ 1,269.16
Muc Off Ludicrous AF (Extrapolated data)	$ 1,898.00
Muc Off Hydro Dynamic (Extrapolated data)	$ 1,955.00
Muc Off Nano Lube (Extrapolated data)	$ 2,282.50
Ab Graphene lube - TEST RESULTS LOCKED BY NDA	

Wet Gravel riding – GRX 810 Groupset (reference for Wet mtb riding as well just factor your groupset component cost vs GRX 810).

GRX 810 Components - Wet gravel / Mtb / Cx	Total Cost Per 10,000km
Mspeedwax New Formula	$ 235.35
Silca Hot Melt	$ 275.85
Silca Synergetic	$ 634.46
Nix Frix Shun	$ 642.30
Tru Tension Tungsten All Weather	$ 724.50
Ceramic Speed UFO Drip New Formula	$ 769.40
Silca SS Drip	$ 844.72
Allied Grax	$ 915.00
Smoove	$ 993.50
Squirt	$ 1,029.00
Tru Tension Tungsten Race (D.A)	$ 1,338.28
Rock N Roll Gold	$ 1,457.44

Cycle Star Gold (Extrapolated Data)	$ 1,478.50
Wend wax 2	$ 1,529.50
Rex Domestique	$ 1,843.50
Revolubes	$ 1,858.50
AB Graphene Wax (Extrapolated data)	$ 2,304.66
White Lightning Epic Ride (Extrapolated data)	$ 2,771.50
Muc Off Ludicrous AF (Extrapolated data)	$ 3,714.00
Muc Off Hydro Dynamic (extrapolated data)	$ 4,248.50
Muc Off Nano Lube (Extrapolated Data)	$ 4,420.00
Ab Graphene lube - TEST RESULTS LOCKED BY NDA	

ZFC Overall Performance Ratings

Race Day Lubricant Road – 6/10

Only if prepped via immersive application – Grax outright efficiency was respectable, albeit up to circa 1.5 slower than the fastest known.

Race Day Lubricant MTB / CX / Gravel – 6/10

Only if prepped via immersive application – Grax outright efficiency was respectable, albeit up to circa 1.5 slower than the fastest known. Grax Dry contamination performance was ok, but I did hope for better.

Everyday Lubricant – 6/10 dry riding – 3/10 for wet riding.

Again Grax was ok overall, however it's wet performance was not spectacular, and the significant initial penetration issues make cleaning and re-applying Grax post wet riding a right pain in the backside vs other lubricant options.

Harsh Conditions Lubricant – 5/10

Grax was pretty mid pack re performance in wet conditions.

Single Application for Long event – 7 to 8/10

Whilst it is not ranking super high at the moment on the league table, the actual result for outright treatment longevity was pretty good – again noting the league table is currently made up mostly of the top performing lubricants tested to date. Again as long as you pre prep via immersive application, Grax will last no problems Flag to Flag for 99% of any events you may wish to tackle including events like Unbound Gravel unless it is very wet.

Final Wrap

I found this review a bit painful to type up as I really like Allied as company, I really like how genuine and how hard they invested to try to bring a brilliant product to market, and I'm pretty peeved at the Tribology company that let them down. Some responsibility for this does rest on Allied, as it is a gamble to have the same company who develops your lubricant be the one who also proves to you that it is the best lubricant. And also some of the glaring errors (in my opinion) in the test results and white paper should have been able to be picked up and questioned hard by Allied before going to market, and it was incumbent on both Allied & the Tribology company to investigate further some results that are just frankly beyond any basic level of logic before going to print.

Aside from that, Grax is a decent lubricant, but i believe / hope they will improve over time. It is far too thick re viscosity creating difficulties for initial penetration, which depending on your riding may be not much of an issue at all, or a real pain the backside.

Like other lubricants of this type (Smoove / squirt) it will feel lovely to ride, and if not over applied + excess thoroughly wiped off post application and working in, drivetrain will remain impressively clean for a long time. It is priced very well, but, I was hoping for better re wear rates especially in what is supposed to be its wheelhouse which is off road – I hope a future iteration (using a different tribology company) will improve Grax, I believe it has strong potential. It is a good first attempt, and it is a solid foundation for a possible market leading contender in future if initial penetration issues can be resolved and if it sets a bit more solid like Smoove for greater contamination resistance especially in dry conditions.

Allied will likely not have ZFC on their Christmas card list, but, for what it is worth, I think Allied are a truly great little company, well worthy of anyone's investment if looking at a new bike. And whilst Grax doesn't live up to the marketing and Test white paper (in my opinion), it is a least a decent lubricant choice, and the intention + investment by Allied is beyond question, they invested heavily and genuinely to bring a top product to market, vs just slapping marketing on top of a rebranded existing lubricant.

Pics from test

End of main test and end of wet contamination block 4 – 4000km.

End of main test and end of wet contamination block 4 – 4000km.

End of main test and end of wet contamination block 4 – 4000km.

*********Extra detail on why must FTT AND FLT for efficiency testing – why long runs on FTT may produce runaway incorrect results for some lubricants**********

First of all, because there do not exist a standard-method of testing bicycle lubes, a paper on the wax-lubricant mechanism in a bicycle chain does not exist (unfortunately).

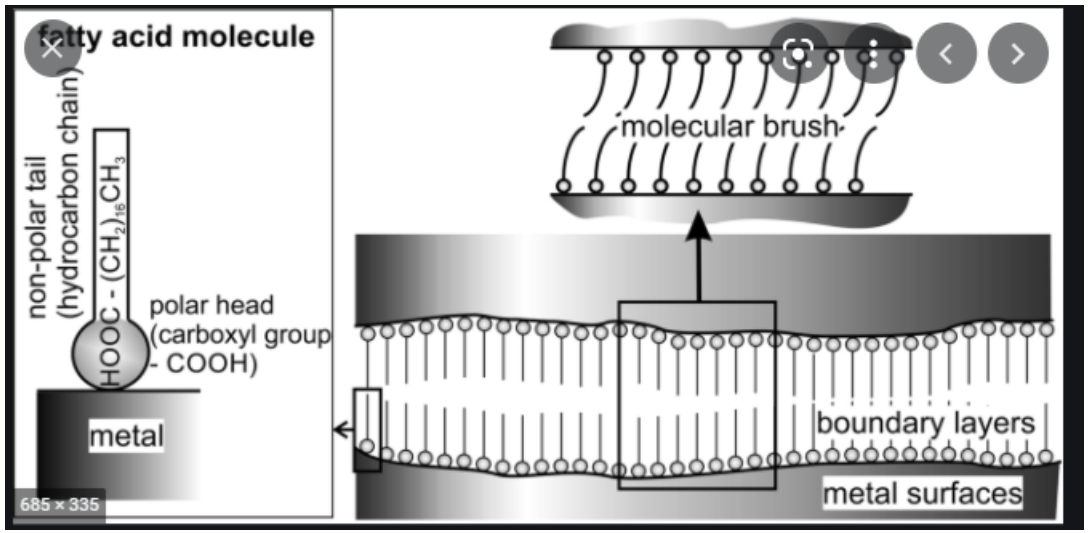
Arguments are therefore strictly based on how I see the world of wax-lubrication, and are not based on extensive literature.

Most wax-lubricants comprises paraffin-wax as it majority wax-content.

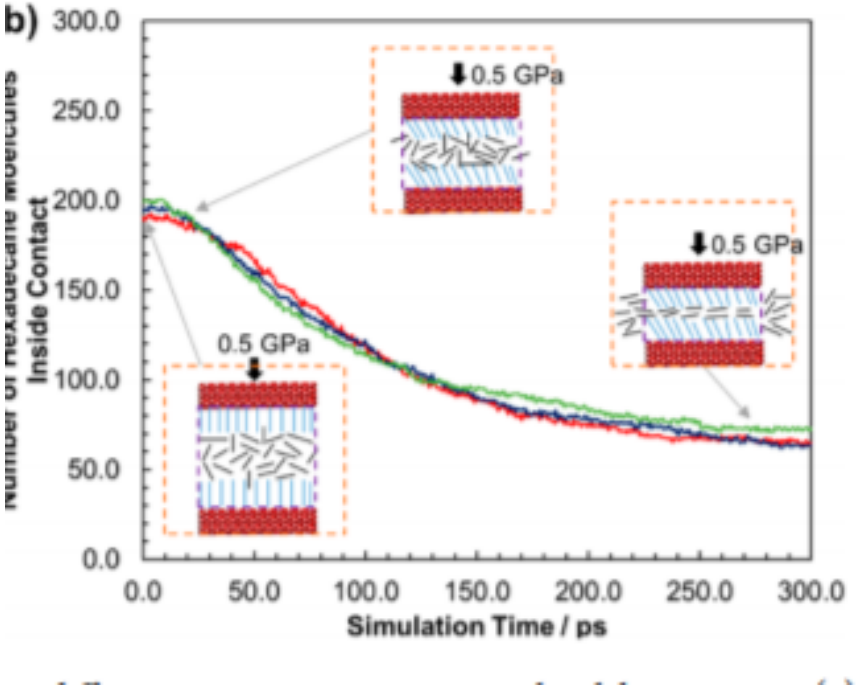
Paraffin wax comprises different sized hydrocarbon alkanes. These alkanes cannot adhere to the metal surface of the bicycle chain, and if no additives are added, then these alkanes-molecules will randomly align inside the links. When the bicycle chain is running on the drive train, then each of these links will bend/stretch or relax depending on where the link is located on the drivetrain.

In order to have a good low friction wax-lube, then a low melting point of the wax-mixture is a key feature. When using the bicycle chain, the chain will not be so hot that all wax inside the chain starts to melt, but when the link is bended/stretched or feel pressure, then the boundary lubrication (remember that is the boundary lubrication that is effective, not the lubrication reservoir) will start to “melt” (flow is a better word). The alkanes will start to move and slide among each other and thereby lubricate the surfaces in the links. However, if the chain links are not allowed to relax as during the FLT, then all of the wax-lubricant will be removed from the chain links. So the FLT procedure is simply to help regenerate the wax inside the links. (see last picture)

If you add for example a fatty acid, then the fatty acid (head) will be able to bind to the metal surface. The alkane-carbon chain (black tail) will stand perpendicular to the metal surface. The paraffin-alkanes will mix with the fatty acid tails and thereby align as them. This will ensure that the wax lubricant is more restricted



As you can see on the last picture then the paraffin wax can move.



A combined FTT/FLT test procedure is the best way of testing bicycle chain lubrication. Several times, we have had two parallel test setup – one chain is run in our lab-setup and one chain is tested on a bicycle used on an indoor track. Comparing chains from these two setups, we see that get identical watt-friction levels. Which in my opinion is the biggest proof that this is the way to test, whereas using only FTT does not give data that is reproducible in real-life.

A previous case where incorrect use of FTT for testing was in my opinion proven beyond doubt;

An open communication on Muc-Off's claims on testing

Following Muc-Off's recent release of their Nanotube Chain, CeramicSpeed have chosen to provide a detailed response aiming to address Muc-Off's claims on testing.

Muc-Off recently released a brochure in connection to the launch of their Nanotube Chain which included data regarding the long-term performance of CeramicSpeed UFO Chains.

The following communication addresses the misleading nature of Muc-Off's data. Based on what we know of Muc-Off's testing procedure, we assume this misleading data is caused by incorrect methods of acquiring 'endurance test' data. We describe the correct test methods, and show the results of a correct test as well the results of a test recreating the misleading data.

In the following paragraph, we will discuss how and why using the wrong test machines can provide misleading data. This is followed by a thorough discussion of how we assume Muc-Off has performed their testing which is supported by a replication of their assumed testing method compared to the correct method. As the results will show, the two different ways of performing the testing, leads to two very different data results.

1.1 How can misleading data be created from an Endurance Test?

Based on the test results Muc-Off presented, we must assume that they performed the 'endurance tests' with their tester in "Full Tension" mode. While this mode provides the most precise measurement of friction in a chain, it is designed to be used only for short-term friction measurements. The "Full Tension" mode should never be used for long-term endurance testing. For long term testing, an Endurance Machine should be used to more accurately simulate an actual bike drivetrain. Alternatively, for the purest 'endurance test' possible, the chain should be ridden on an actual bike for several hours with pre-ride and post-ride friction measurements taken using the Full Tension Tester.

In the following we will discuss how a Full Tension Tester used for long-term testing will cause misleading data.

1.2 Why should the Full Tension Tester not be used for long-term testing?

When attempting to accurately determine the "Friction vs. Time" graph for endurance testing purposes, both the Full Tension Tester and an Endurance Machine must be used. The Full Tension Tester is used solely for obtaining friction measurements and the Endurance Machine is used for subjecting the chain to long-term run times under load.

The Full Tension Tester measures chain friction by applying high levels of tension symmetrically on two chain spans. Rear derailleur chain spans are not present on a Full Tension Tester. Granted, this type of tester produces the most precise chain friction measurements of any test method. Yet the constant tension loading conditions do not mimic a true bicycle drivetrain, and inaccurate results for long-term chain endurance measurements can occur.

Simply put, the Full Tension Tester was designed for short-term, high-precision friction measurements. To perform proper endurance testing of a chain, the chain should be tested on Full Tension Tester for an initial friction measurement, then swapped and long-term tested on a rig that is set up to represent a bicycle drivetrain, with true drive power at the ring, load on the cog, and a rear derailleur setup, such as an Endurance Machine, or even an actual bicycle. After the chain is run under load for a given amount of time, the chain should be transferred back to the Full Tension Tester to get a subsequent friction measurement.

It is irrelevant to test whether a chain remains fast (retains low friction) for long periods of time on the Full Tension Tester, as no bike chain is ever at symmetrical full tension for several hours. Put differently, the Full Tension Tester does not reflect a real-use scenario.

Full descriptions of the two types of equipment can be found on the Friction Facts site.

http://www.friction-facts.com/equipment/full-tension-test-method

http://www.friction-facts.com/equipment/chain-full-load

1.3 The ‘Slacking Effect’

The issues with using the Full Tension Tester for long term testing arise from the fact that the chain is always under heavy tension, on both upper and lower spans, and the chain is never allowed to slack. In a true bicycle drivetrain, the chain slacks as it snakes through the rear derailleur. When the chain slacks, the lubricants (solids or liquids), on a microscopic level, are redistributed, and the contact lines of the sliding surfaces are constantly shifting, continuously creating new contact lines of lubricant. This slacking refreshes the chain and allows the lubricant to perform for long durations.

This ‘slacking effect’ was discovered in 2015 by Friction Facts. It was recognized that during longer testing periods on the Full Tension Tester, some lubricants would show abnormal increases in friction. During testing of a chain experiencing this abnormal increase in friction on the Full Tension Tester, the chain friction would instantly drop back down to a normal level, yet slowly creep up again over time, if the load was removed for a few seconds, with the equipment still turning (ie, the chain was slacked), and the load then re-applied. This phenomenon could easily be repeated many times during a single long-term test run, quickly lifting and re-applying the load to slack the chain and the friction levels would return to normal.

This behaviour of rising friction levels over longer periods due to a fully-tensed chain is obviously not conducive to accurate long-term testing. To confirm the Full Tension Tester was not suitable for long term measurements based on the theory that the Full Tension Tester did not allow slacking, endurance testing was performed on multiple chain samples to expose the differences between using only the Full Tension Tester versus the Full Tension/Endurance Machine combination. The Full Tension/Endurance Machine combination produced the repeatable and realistic results expected in this type of a long-term test situation.

After confirmation testing proved this theory, the findings led to the protocol of using 1) a full-fledged replica of a bicycle drivetrain for longevity loading (the Endurance Machine), and 2) using the Full Tension Tester at pre-described intervals for obtaining precision friction measurements. Undoubtedly, the findings proved the Full Tension Tester cannot be used alone for long term endurance tests.

Because of this discovery, Friction Facts developed a new Endurance Test protocol, which incorporated the use of an Endurance Machine in conjunction with the Full Tension Tester for accurate, fair, and repeatable "friction vs. time" endurance testing. In the following paragraphs, we will discuss why it appears that Muc-Off are basing their test results on incorrect testing methods and as a consequence of that, has published misleading data. The discussion is based on assumptions since we were not present during the testing, but these assumptions is supported by a thorough replication of the assumed testing method compared to the correct testing methods as being discussed in the previous paragraphs.

To get the full understanding of how and why we assume Muc-Off has come up with this data, please read the below discussion.

2.1 Why is it assumed that Muc-Off performed the endurance testing with only the Full Tension Tester?

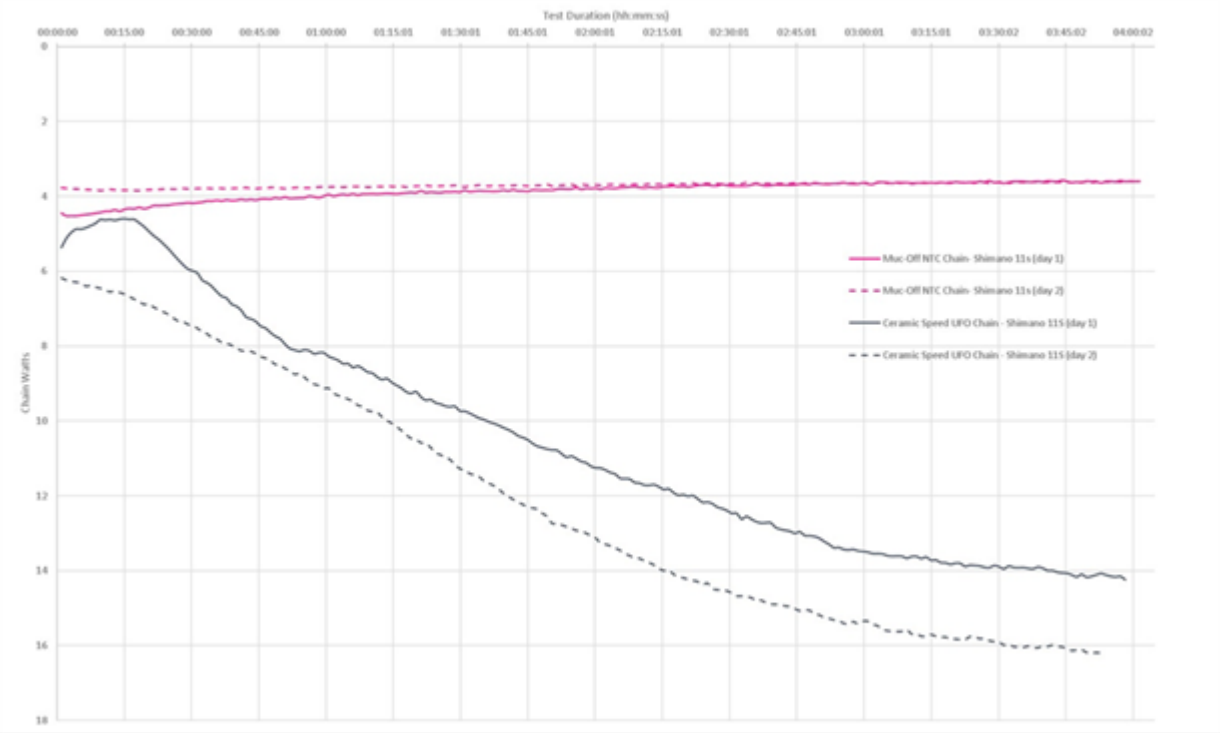
The 'slacking effect' abnormality is easily detectable on any "chain friction vs. time" graph. The slacking effect presents itself as a relatively large rate-of-increase in friction over time, with a drastic decrease in friction when the full tension is removed and re-applied, followed by a subsequent increase in friction similar to the initial increase in friction before the chain was slacked.

For this document, Friction Facts performed an endurance test using the incorrect test procedures, effortlessly recreating similar (and incorrect) data to the data that Muc-Off published. A test using the correct procedures was also performed, highlighting the procedural errors, and proving the UFO Chain is a 4-watt chain, not a 14-watt chain. This replication of data can be seen in a later section.

Muc-Off originally produced the "UFO chain friction vs time" graph with two days of data, Day 1 and Day 2, using the same UFO Chain for both days (see Graph 1). Note how the UFO Chain's friction levels dropped from 14+ watts down to 6 watts when the chain was removed from the Full Tension Tester after Day 1 and re-tested for the subsequent Day 2 test run.

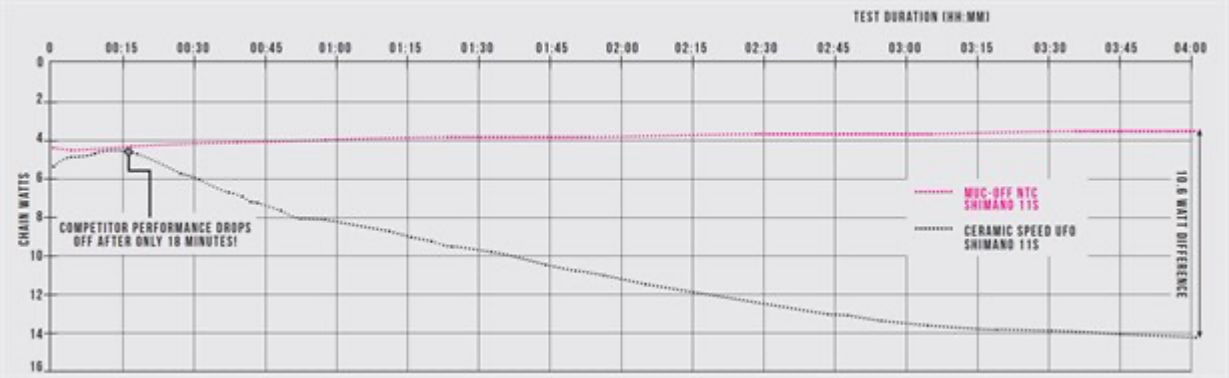
This drastic drop in the UFO Chain friction obviously begs the question; How could a chain get 8 watts faster by sitting overnight? The answer is it didn't get 8 watts faster. The chain was never a "14-watt chain" to begin with, even though the Full Tension Tester was putting out this data. The Full Tension Tester was producing incorrect and excessively high friction readings due to the long duration test. This is undoubtedly due to the 'slacking effect", and is a tell-tale sign that the Full Tension Tester was employed incorrectly for long term testing in this case.

Graph 1: Muc-Off's original graph showing a UFO Chain decreasing 8 watts overnight, between Day 1 and Day 2 testing.



Muc-Off's original graph indicates something is potentially flawed with the test due to the instantaneous drop in friction on the same UFO Chain between test runs. When the recent NTC Chain brochure was launched, the "Day 2" data containing the anomaly was removed from the graph (see Graph 2).

Graph 2: The "revised" graph as seen in the NTC Brochure. The Day 2 data was deleted for the publication of the NTC brochure.



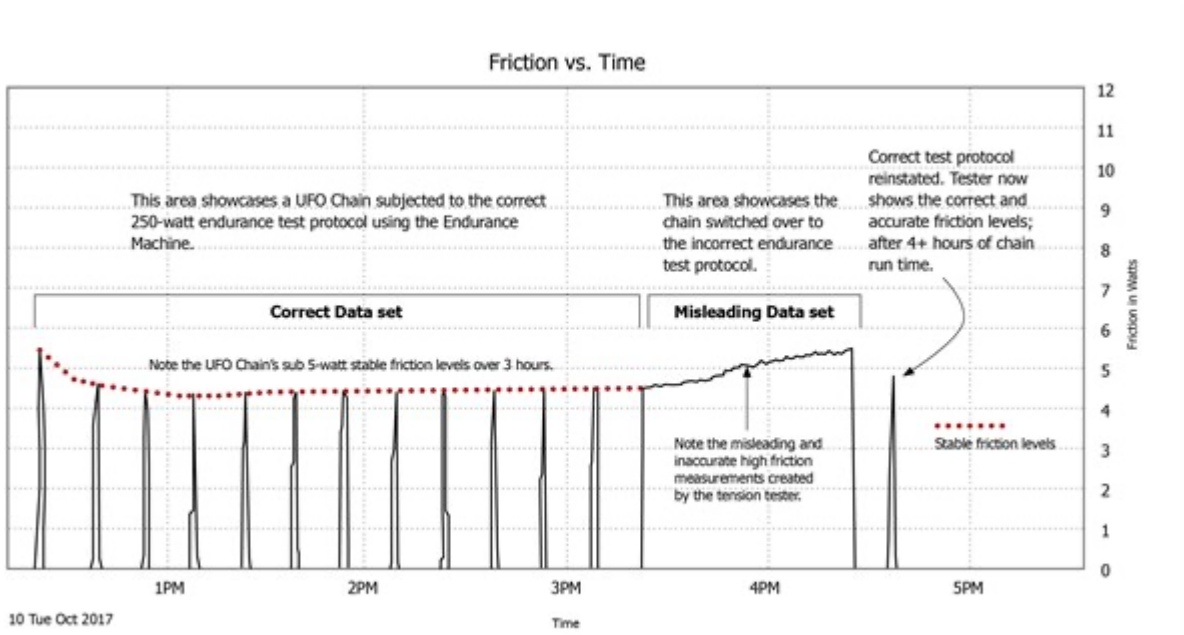
CeramicSpeed has no way of knowing if Muc-Off is aware of the consequences of the ‘slacking effect’ phenomena or indeed why the graph was revised.

Regardless of that, an 8-watt immediate decrease in chain friction between test runs, on the same chain, should quickly raise eyebrows in any situation, and Muc-Off ought to have revisited their test.

2.2 Replication of Muc-Off’s Endurance Test and Subsequent Data Collected

CeramicSpeed has carried out an endurance test to illustrate the difference between a correct and incorrect test protocol.

A single CeramicSpeed UFO Racing Chain (KMC version for the sake of testing) was run continuously for a 4-hour endurance test. The first 3 hours of the test were performed properly. The 4th hour was performed incorrectly. The graph below is an actual “print screen” from the tester. It has not been altered or manipulated in any way except for the added text.



For the first three hours, the chain was run under 250W load on the Endurance Machine. At 15-minute intervals, the chain was removed from the Endurance Machine, placed onto the Full Tension Tester for a 1-minute friction measurement, and then placed back on the Endurance Machine. Note the stable, realistic, and expected behaviour of the UFO Chain. The friction levels maintain a mid 4-watt range for the first three hours of the test.

After the 3-hour correct test, the incorrect test procedure was initiated. The chain was removed from the Endurance Machine and placed on the Full Tension Tester. However, the chain was allowed to remain on the Tension Tester for one hour. Note the relatively fast increase in friction levels when the chain is on the Full Tension Tester for this long period of time. This steady increase in friction during the 4th hour is very similar to the UFO Chain friction increase seen in Muc-Off's graph.

After an hour of the incorrect procedure, the chain was removed from the Full Tension Tester and placed back on the Endurance Machine for 10 minutes, to allow the chain to slack through the rear derailleur spans, and then a final friction reading was taken on the Full Tension Tester. The final friction reading was 4.75W.

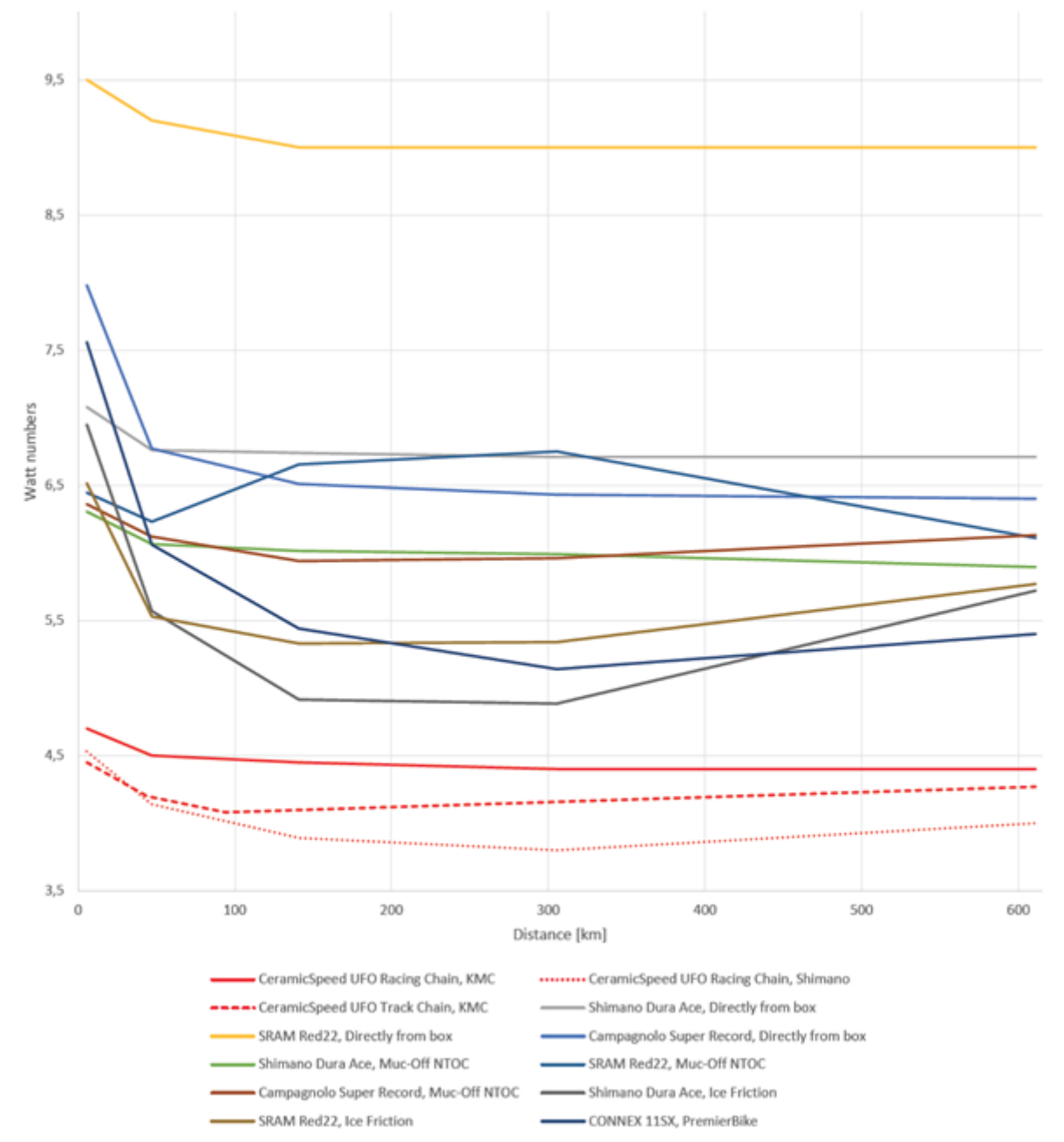
This test shows how friction measurements can incorrectly climb when a chain is run long-term on a Full Tension Tester, and how the friction almost immediately drops to original levels when the chain is taken off the tester and allowed to slack. The data from this incorrect test is similar to Muc-Off's original graph. The chain friction increased significantly during Day 1 under Full Tension, then suddenly dropped due to slacking at the end of Day 1, then the friction increased again during Day 2 under Full Tension Tester.

This test also proves that a UFO Chain maintains sub 5-watt friction level at 250W over 4 hours.

As mentioned earlier, the Full Tension Tester is the only known way to measure chain friction precisely, but must be used for short durations to obtain accurate friction readings.

Both CeramicSpeed's Friction Facts lab in the US, and their test lab at the Denmark headquarters have matching Full Tension Testers and Endurance Machines. Any and all endurance testing is performed with the proper protocol, by using these two machines together.

Several months ago, CeramicSpeed tested various factory-treated chains for comparison purposes. The graph below shows the results a properly performed, realistic endurance test, using the two machines.


9,5
8,5
7,5
6,5
5,5
4,5
3,5
Watt numbers
0
100
200
300
400
500
600
Distance [km]
CeramicSpeed UFO Racing Chain, KMC
CeramicSpeed UFO Racing Chain, Shimano
CeramicSpeed UFO Track Chain, KMC
Shimano Dura Ace, Directly from box
SRAM Red22, Directly from box
Campagnolo Super Record, Directly from box
Shimano Dura Ace, Muc-Off NTOC
SRAM Red22, Muc-Off NTOC
Campagnolo Super Record, Muc-Off NTOC
Shimano Dura Ace, Ice Friction
SRAM Red22, Ice Friction
CONNEX 11SX, PremierBike

Please note, that the Muc-Off Nanotube Chain wasn't released at the time this testing was performed. The Muc-Off chain in this graph is therefore not the Nanotube Chain but the Muc-Off NTOC Chain (Nanotube Optimised Chain).

CeramicSpeed has publicly posted the "Endurance Test Protocol" for purposes of transparency and integrity in test methodology.

Further info also on this link here;

https://www.ceramicspeed.com/en/cycling/inside/test-data-reports/racing-chains