Zero Friction Cycling

Intro re worlds most in depth and trusted independent lubricant performance testing - understanding the protocol in brief and the data table results.

Welcome to re-vamped test data wrap from the worlds most in depth contolled lubricant testing. Whilst the previous graphs were more eye catching than a data table, they were a) getting to crowded, and b) too hard to work through with regards to block by block performance breakdown and what it means for your riding - ie road, gravel / mtb, extreme conditions etc.

The most relatable metric was taking that wear rate data, and clearly showing what it means with regards to rate of wear for your drive train components, and the cost to you to run your drivetrain per 10,000km based on that lubricants wear rate.

The cost to run per 10,000km was the most popular component of previous graphs - so this has been expanded across Ultegra and Dura Ace components for road. Previously it was just ultegra, however Dura ace highlights much better the benefits of a lubricant that may cost more per bottle, but delivers vastly lower wear rates. The more expensive the drive train components, the cost of the lubricant becomes a very small part of the equation - the component wear rate will be the main cost to run driver

The cost to run has also been expanded across dry, wet & extreme conditions offroad riding using GRX 810 groupset component cost based on wear rate performance in those test blocks.

ZFC test protocol in brief - (I have full test brief on website but not many will read it :)). Most lubricant tests are conducted in clean lab conditions for outright efficiency. This may be tracked over a period ranging anywhere from typically 4hrs to 14 hours.
It is extremely rare for any contamination to be introduced in these lab tests. Lubricants are often applied via immersive / ultrasonic application which is not how lubricant is typically applied by consumer.

This provides a relatively small amount of usefull data for a cyclist. It is maybe ok if looking at data for a time trial or good conditions road race and you are going to fully strip clean chain and immersively apply lubricant post race, but for the many who simply add lube, then later on wipe chain and add more lube - this data will not provide an indication of its ongoing performance.

The lab tests also do not provide any substantiation of most common claims found on lubricants such as "Repels dust dirt & grime", "Cleans as it lubricates", "Forms a high strength film / membrane preventing metal on metal or contamination on metal wear

The lab tests do not provide any information with regards to any possible initial penetration issues of lubricant when applied to a properly cleaned chain. Penetration issues can be common and cause notable wear and friction for certain lubricant types.
This is a very important aspect if you are the type of cyclist who likes to maintain drivetrain by regularly properly cleaning chain and re-applying lubriant

The Zero Friction Cycling test protocol assess if initial penetration issue is present. It assess dry dust contamination resistance. Assess ability to clear contamination. Assess wet contamination performance. Assess Extreme contamination performance.
Testing per lubricant can reach up to 10,000km depending on its performance across the main test and single application longevity tests.

The ZFC test protocol is not designed to provide a real world longevity result that relates to you personally, however it is more accurate that real world testing. Why?
Real world testing is simply all over the place. All of the key variables are not controlled, such as load, time between re-lubes, what contamination is introduced and when is it introduced into the test. Ie all it takes is for a bit more contamination to be introduced early, and at a time when the ride is a higher intensity training ride, and this will greatly effect wear rate. Real world ride testing needs same chain and same lubricant tested many times over thousands of km's to deliver a ballpark result.

I have accurately tracked wear rate for 9 chains across my own road ride training using same chain and same lubricant & maintenance. Results varied from 4000km to 6,500km to 0.5%. This is a test result variance of over 60%.

By controlling all key variables of training load, re-lube intervals, contamination type, and same amount introduced at same points in test, ZFC test protocol has demonstrated a test variance of +/- 5%, with almost 300,000km of controlled testing completed at time of this document update (march 2021).

Your results may differ to results attained in ZFC test as you may ride with higher or lower load, expose chain to contamination earlier, push lubricant treatment lifespans further, or less, or conduct regular and good maintenance. The key message is the wear rate correlation is extremely likely to correspond with what you attain for that lubricant vs other lubricants tested.

Whilst the ZFC test does not provide an efficiency loss figure is watts - the correlation between wear rates and lubricant efficiency have proven to be extremely robust, and the times when a lubricant has also been efficiency tested in a reliable and accurate test lab, the performance of the lubricant has aligned with the lubricants wear rate. This makes sense. Quite simply it when a chain is wearing, that is hardened steel parts wearing down. Wearing through hardened steel parts flat out takes friction. If you set to sanding back a steel part with a frictionless cloth, nothing will happen. If you set to it with a bastard file, something will happen. Is your lubricant a grinding paste masquerading as a chain lubricant, or is does it remain a super slippery liquid / chain coating.

Where possible, if I have an accurate trusted efficiency loss figure for the lubricant (ie from Ceramic Speed research lab in Denmark) this will be covered in the lubricant detail review. When we have both the efficiency loss result as well as assessment of lubricant from ZFC test on initial penetration issues or not, dry contamination resistance, wet contamination resistance, ability to clear contamination, single application longevity test for road, gravel and extreme events - we have a very complete picture of the lubricants performance. Quite some number of the the worlds biggest players in the chain lubricant market have used ZFC testing to check & benchmark their lubricants performance and claims even when they have attained precise efficiency test results.

The challenge of lubricating your chain is extreme. Your chain has many moving parts, it is by far the hardest working mechanical part on your bike, and it is completely exposed to the elements. Many lubricants sold are in themselves perfectly fine lubricants - if they ran in a clean sealed environment (such as how your bearings get to run), they would likely remain performing similar to lab test results for a long time. However that is not the environment they run in, and if every particle of airborne dust sticks on contact and lubricant quickly becomes abrasive - this shows up quickly in the ZFC test protocol. The test protocol and the parts wear rates recorded is much more relatable to your real world riding even if your personal results may vary depending on various factors outlined above.

Finally - on the single application longevity data (separate page) a new much more comprehensive test was introduced in October 2020. Previous test yielded limited data for the many questions re what lubricant for what event that ZFC receives, and so a new much more exhaustive single application longevity test is now conducted to cover road, gravel / mtb, and extreme conditions. Over time i need to re-test lubricants through the new single application longevity test, albeit this will take some time, and also only be done for lubricants that are worth testing

TO THE DATA! The Truth Shall Set your Friction Free!

Cost to Run per 10,000km - Road roading mixed conditions (based on wear rate data from main 5000km test with dry and wet contamination blocks)

(NOTE - "I.P" = wear rate results impacted by significant initial penetration issues which resulted in very high wear rates in block 1 of test. Wear rate results + cost to run calcs can be much lower if initial penetration issue negated - ie via immersive application vs manufacturer application instructions. "D.A" = lubricant was re applied at double the rate vs standard test protocol intervals due to short treatment lifespan. In the case of immersive waxes, bags of wax used was not doubled, simply the number of re-waxes)

Ultegra 11spd Components	Lubricant Cost	Number of chains worn	Chains Cost	Number of Cassettes Worn	Cassettes Cost	Chainrings Worn	Chain rings cost	Total Cost Per 10,000km
Mspeedwax Double Application (D.A)	$ 89.80	0.4	$ 20.00	0.2	$ 22.00	0.1	$ 14.70	$ 146.50
Molten Speed Wax	$ 134.70	0.4	$ 20.00	0.2	$ 22.00	0.1	$ 14.70	$ 191.40
Silca Hot Melt	$ 158.80	0.4	$ 20.00	0.2	$ 22.00	0.1	$ 14.70	$ 215.50
Ceramic Spd UFO Drip V 2.0	$ 84.43	1.1	$ 55.00	0.6	$ 60.50	0.2	$ 37.80	$ 237.73
Silca SS Drip	$ 80.92	1.5	$ 75.00	0.75	$ 82.50	0.25	$ 52.50	$ 290.92
Nix Frix Shun	$ 14.85	2.3	$ 115.00	1.15	$ 126.50	0.38	$ 79.80	$ 336.15
Smoove (I.P)	$ 25.00	2.26	$ 113.00	1.1	$ 124.30	0.4	$ 79.80	$ 342.10
Squirt - (I.P)	$ 18.75	2.5	$ 125.00	1.25	$ 137.50	0.42	$ 88.20	$ 369.45
Rock N Roll Gold	$ 67.10	2.9	$ 145.00	1.5	$ 159.00	0.5	$ 100.80	$ 471.90
Tru Tension Tungsten All Weather (I.P)	$ 68.00	3.4	$ 170.00	1.7	$ 187.00	0.6	$ 126.00	$ 551.00
Wend wax 2	$ 112.00	3.3	$ 165.00	1.7	$ 181.50	0.6	$ 115.50	$ 574.00
Cycle Star Gold	$ 140.00	3.3	$ 165.00	1.7	$ 181.50	0.6	$ 115.50	$ 602.00
Tru Tension Tungsten Race (D.A)	$ 399.84	1.6	$ 80.00	0.8	$ 88.00	0.3	$ 63.00	$ 630.84
White Lightning Epic Ride	$ 118.00	4.4	$ 220.00	2.2	$ 242.00	0.74	$ 155.40	$ 735.40
Muc Off Hydro Dynamic	$ 99.75	5	$ 250.00	2.5	$ 275.00	0.8	$ 174.30	$ 799.05
Muc Off Nano Lube	$ 200.00	7.3	$ 365.00	3.7	$ 401.50	1.2	$ 256.20	$ 1,222.70

(NOTE - "I.P" = wear rate results impacted by significant initial penetration issues which resulted in very high wear rates in block 1 of test. Wear rate results + cost to run calcs can be much lower if initial penetration issue negated - ie via immersive application vs manufacturer application instructions. "D.A" = lubricant was re applied at double the rate vs standard test protocol intervals due to short treatment lifespan. In the case of immersive waxes, bags of wax used was not doubled, simply the number of re-waxes)

Dura Ace 11spd Components	Lubricant Cost	Number of chains worn	Chains Cost	Number of Cassettes Worn	Cassettes Cost	Chainrings Worn	Chain rings cost	Total Cost Per 10,000km
Molten Speed Wax	$ 89.80	0.4	$ 20.00	0.4	$ 132.00	0.1	$ 28.00	$ 269.80
Mspeedwax Double Application (D.A)	$ 89.80	0.4	$ 20.00	0.4	$ 132.00	0.1	$ 28.00	$ 269.80
Silca Hot Melt	$ 158.80	0.4	$ 20.00	0.4	$ 132.00	0.1	$ 28.00	$ 338.80
Ceramic Spd UFO Drip V 2.0	$ 84.43	1.1	$ 99.00	1.1	$ 363.00	0.2	$ 80.00	$ 626.43
Silca SS Drip	$ 80.92	1.5	$ 135.00	1.5	$ 495.00	0.25	$ 100.00	$ 810.92
Nix Frix Shun	$ 14.85	2.3	$ 207.00	2.3	$ 759.00	0.38	$ 152.00	$ 1,132.85
Smoove (I.P)	$ 25.00	2.26	$ 203.40	2.26	$ 745.80	0.4	$ 160.00	$ 1,134.20
Tru Tension Tungsten Race (D.A)	$ 399.84	1.6	$ 144.00	1.6	$ 528.00	0.3	$ 120.00	$ 1,191.84
Squirt - (I.P)	$ 18.75	2.5	$ 225.00	2.5	$ 825.00	0.42	$ 168.00	$ 1,236.75
Rock N Roll Gold	$ 67.10	2.9	$ 261.00	2.9	$ 957.00	0.5	$ 192.00	$ 1,477.10
Tru Tension Tungsten All Weather (I.P)	$ 68.00	3.4	$ 306.00	3.4	$ 1,122.00	0.6	$ 240.00	$ 1,736.00
Wend wax 2	$ 112.00	3.3	$ 297.00	3.3	$ 1,089.00	0.6	$ 240.00	$ 1,738.00
Cycle Star Gold	$ 140.00	3.3	$ 297.00	3.3	$ 1,089.00	0.6	$ 240.00	$ 1,766.00
White Lightning Epic Ride	$ 118.00	4.4	$ 396.00	4.4	$ 1,452.00	0.74	$ 196.00	$ 2,162.00
Muc Off Hydro Dynamic	$ 99.75	5	$ 450.00	5	$ 1,650.00	0.8	$ 320.00	$ 2,519.75
Muc Off Nano Lube	$ 200.00	7.3	$ 657.00	7.3	$ 2,409.00	1.2	$ 488.00	$ 3,754.00

Cost to Run per 10,000km - Gravel / MTB / CX - Dry dusty conditions - based on wear rate data from dry contamination test block

(NOTE - "D.A" = lubricant was re applied at double the rate vs standard test protocol intervals due to short treatment lifespan. In the case of immersive waxes, bags of wax used was not doubled, simply the number of re-waxes)

GRX 810 Components - Dry gravel / Mtb / Cx	Lubricant Cost	Number of chains worn	Chains Cost	Number of Cassettes Worn	Cassettes Cost	Chainrings Worn	Chain rings cost	Total Cost Per 10,000km
Silca SS Drip	$ 91.72	0.6	$ 31.25	0.3	$ 32.50	0.1	$ 25.00	$ 180.47
Mspeedwax Double Application (D.A)	$ 125.72	0.5	$ 25.00	0.3	$ 32.50	0.1	$ 25.00	$ 208.22
Ceramic Spd UFO Drip V 2.0	$ 115.40	0.8	$ 37.50	0.4	$ 48.75	0.1	$ 25.00	$ 226.65
Tru Tension Tungsten All Weather	$ 96.00	1.3	$ 62.50	0.6	$ 81.25	0.3	$ 50.00	$ 289.75
Silca Hot Melt	$ 232.72	0.5	$ 25.00	0.3	$ 32.50	0.1	$ 25.00	$ 315.22
Smoove	$ 35.00	2.1	$ 106.25	1.1	$ 146.25	0.4	$ 75.00	$ 362.50
Molten Speed Wax	$ 167.58	1.5	$ 75.00	0.8	$ 97.50	0.3	$ 50.00	$ 390.08
Squirt	$ 27.00	2.2	$ 137.50	1.4	$ 178.75	0.5	$ 100.00	$ 443.25
Nix Frix Shun	$ 19.80	3.4	$ 168.75	1.8	$ 227.50	0.6	$ 125.00	$ 541.05
Rock N Roll Gold	$ 93.94	3.6	$ 181.25	1.8	$ 235.63	0.6	$ 125.00	$ 635.82
Tru Tension Tungsten Race (D.A)	$ 559.78	0.5	$ 25.00	0.3	$ 32.50	0.1	$ 25.00	$ 642.28
Cycle Star Gold	$ 196.00	4.0	$ 193.75	1.9	$ 243.75	0.6	$ 125.00	$ 758.50
Wend wax 2	$ 154.00	4.3	$ 212.50	2.1	$ 276.25	0.8	$ 150.00	$ 792.75
White Lightning Epic Ride	$ 166.00	7.1	$ 356.25	3.5	$ 455.00	1.1	$ 225.00	$ 1,202.25
Muc Off Hydro Dynamic	$ 140.00	12.4	$ 618.75	6.1	$ 796.25	2.0	$ 400.00	$ 1,955.00
Muc Off Nano Lube	$ 280.00	13.5	$ 675.00	6.8	$ 877.50	2.3	$ 450.00	$ 2,282.50

Cost to Run per 10,000km - Gravel / MTB / CX - Wet abrasive conditions - based on wear rate data from wet contamination test block

(NOTE - "D.A" = lubricant was re applied at double the rate vs standard test protocol intervals due to short treatment lifespan. In the case of immersive waxes, bags of wax used was not doubled, simply the number of re-waxes)

(*Extrapolated data - Used when lubricant on test reached chain wear ratw limit (0.5%) before reaching this test block. In that case, data used here is double the wear rate attained during dry contamination block. Extrapolated data has much less accuracy than measured data. It is possible that a lubricant does not in fact perform twice as poorly in wet contamination as it did vs dry contaminaton block. It is possible it may perform worse. If a lubricant did not even make it to wet contamination block, it is quite frankly in ZFC opinion, demonstrating extremely concerning performance. Some of the top lubricants tested have reached wet contamination block with less that 10% of their wear allowance, whereas the worst tested have been over 150% of wear allowance and test had to be stopped at this point.

GRX 810 Components - Wet gravel / Mtb / Cx	Lubricant Cost	Number of chains worn	Chains Cost	Number of Cassettes Worn	Cassettes Cost	Chainrings Worn	Chain rings cost	Total Cost Per 10,000km
Mspeedwax Double Application (D.A)	$ 125.72	0.9	$ 36.00	0.5	$ 58.50	0.2	$ 30.00	$ 250.22
Molten Speed Wax	$ 167.58	1.2	$ 48.00	0.6	$ 78.00	0.2	$ 30.00	$ 323.58
Silca Hot Melt	$ 232.72	1.2	$ 48.00	0.6	$ 78.00	0.2	$ 30.00	$ 388.72
Nix Frix Shun	$ 19.80	4.4	$ 174.00	2.1	$ 273.00	0.8	$ 150.00	$ 616.80
Tru Tension Tungsten All Weather	$ 96.00	4.7	$ 186.00	2.3	$ 292.50	0.8	$ 150.00	$ 724.50
Ceramic Spd UFO Drip V 2.0	$ 115.40	4.8	$ 192.00	2.4	$ 312.00	0.8	$ 150.00	$ 769.40
Silca SS Drip	$ 91.72	5.6	$ 222.00	2.7	$ 351.00	0.9	$ 180.00	$ 844.72
Smoove	$ 35.00	6.8	$ 270.00	3.5	$ 448.50	1.2	$ 240.00	$ 993.50
Squirt	$ 27.00	7.4	$ 294.00	3.6	$ 468.00	1.2	$ 240.00	$ 1,029.00
Tru Tension Tungsten Race (D.A)	$ 559.78	5.7	$ 228.00	2.9	$ 370.50	0.9	$ 180.00	$ 1,338.28
Rock N Roll Gold	$ 93.94	9.8	$ 390.00	5.0	$ 643.50	1.7	$ 330.00	$ 1,457.44
Cycle Star Gold (Extrapolated Data)	$ 196.00	9.5	$ 378.00	4.7	$ 604.50	1.5	$ 300.00	$ 1,478.50
Wend wax 2	$ 154.00	10.1	$ 402.00	5.0	$ 643.50	1.7	$ 330.00	$ 1,529.50
White Lightning Epic Ride (Extrapolated data)	$ 166.00	18.8	$ 750.00	9.8	$ 1,225.50	3.2	$ 630.00	$ 2,771.50
Muc Off Hydro Dynamic (extrapolated data)	$ 140.00	29.7	$ 1,188.00	14.9	$ 1,930.50	5.0	$ 990.00	$ 4,248.50
Muc Off Nano Lube (Extrapolated Data)	$ 280.00	30.0	$ 1,200.00	15.0	$ 1,950.00	5.0	$ 990.00	$ 4,420.00

Cost to Run per 10,000km - Gravel / MTB / CX - Wet abrasive conditions - based on wear rate data from Extreme Contamination test block

***Note - it would take most riders many seasons to complete 10,000km of full mudder cx / mtb riding - and of course this is the worst case scenaro, and not likely a drivetrain would ever be subjected to such (except those competing in Belgian CX seasons :). Drivetrains are typically replaced maybe once before a new bike is purchased after a few seasons have passed and the cyclist starts over. The below of course also works on the premise one is replacing their drivetrain when chain wear reaches 0.5% mark - something that is not common in such riding -what typically occurs with drivetrains ridden frequently in such conditions is drivetrain components are replaced when they simply dont work anymore, and are way past recommended replacment marks. If you run until this point riding most times in full mudder conditions you will have lower cost to run vs below, but you will be spending most of your riding with extremely high friction. Some of the worst performing lubricants tested after contamination blocks have been circa 20w loss at 250w load, which equals circa 40w loss at 500w load. The very best are still around one quarter of those losses. Obviously the best choice is to choose a lubricant that has performed extremely well here, and replace chains at 0.5% - with the right lubricant and maintenance choices you can have your cake and eat it too - very low friction all the time, very low wear, and very low running costs.**

(NOTE - "D.A" = lubricant was re applied at double the rate vs standard test protocol intervals due to short treatment lifespan. In the case of immersive waxes, bags of wax used was not doubled, simply the number of re-waxes)

(*Extrapolated data - Used when lubricant on test reached chain wear ratw limit (0.5%) before reaching this test block. In that case, data used here is double the wear rate attained during WET contamination block. Extrapolated data has much less accuracy than measured data. It is possible that a lubricant does not in fact perform twice as poorly in Extreme contamination as it did vs Wet contaminaton block. It is possible it may perform worse. The worst lubricants tested thus far did not even make it to wet contamination block, and so have a doulbe extrapolation (ie their wet contamination block was extrapolated by doubling dry contamination block performance, and extreme contamination by doubling their extrapolated wet contamination. This makes their calculated result ballpark indeed - but again lubricants that zoomed past wear rate allowance by end of dry contamination block are not going to give you a happy result in vastly worse conditions - so whilst the numbers may not quite be as scary as shown here (or they may be even more scary, we just don't know) - for love of your drivetrain - ZFC recommends simply not to risk them when other lubricants have proven to deliver extremely low wear rates.

GRX 810 Components - Extreme Conditions (full mud cx etc)	Lubricant Cost	Number of chains worn	Chains Cost	Number of Cassettes Worn	Cassettes Cost	Chainrings Worn	Chain rings cost	Total Cost Per 10,000km
Silca Hot Melt	$ 232.72	1.6	$ 78.75	0.7	$ 91.00	0.2	$ 35.00	$ 437.47
Mspeedwax Double Application (D.A)	$ 125.72	4.9	$ 245.00	2.5	$ 318.50	0.9	$ 175.00	$ 864.22
Tru Tension Tungsten All Weather	$ 96.00	5.6	$ 280.00	2.8	$ 364.00	0.9	$ 175.00	$ 915.00
Ceramic Spd UFO Drip V 2.0	$ 115.40	6.5	$ 323.75	3.2	$ 409.50	1.1	$ 210.00	$ 1,058.65
Nix Frix Shun (Extrapolated Data)	$ 19.80	10.0	$ 498.75	5.1	$ 659.75	1.8	$ 350.00	$ 1,528.30
Silca Drip Batch 2	$ 91.72	11.6	$ 577.50	5.8	$ 750.75	1.9	$ 385.00	$ 1,804.97
Molten Speed Wax	$ 167.58	13.7	$ 682.50	6.8	$ 887.25	2.3	$ 455.00	$ 2,192.33
Smoove (Extrapolated Data)	$ 35.00	15.8	$ 787.50	7.9	$ 1,023.75	2.6	$ 525.00	$ 2,371.25
Tru Tension Tungsten Race (D.A)	$ 559.78	13.5	$ 673.75	6.7	$ 864.50	2.3	$ 455.00	$ 2,553.03
Squirt (Extrapolated Data)	$ 27.00	17.2	$ 857.50	8.6	$ 1,114.75	2.8	$ 560.00	$ 2,559.25
Rock N Roll Gold (Extrapolated Data)	$ 93.94	22.8	$ 1,137.50	11.4	$ 1,478.00	3.9	$ 770.00	$ 3,479.44
Wend wax 2 (Extrapolated Data)	$ 154.00	23.3	$ 1,163.75	11.7	$ 1,524.25	3.9	$ 770.00	$ 3,612.00
Cycle Star Gold (Extrapolated Data) (Bankrupt?)	$ 364.00	21.9	$ 1,093.75	11.0	$ 1,433.25	3.7	$ 735.00	$ 3,626.00
White Lightning Epic Ride (Extrapolated Data)	$ 166.00	43.8	$ 2,187.50	21.9	$ 2,843.75	7.4	$ 1,470.00	$ 6,667.25
Muc Off Hydro Dynamic (Extrapolated Data)	$ 140.00	69.3	$ 3,465.00	34.7	$ 4,504.00	11.6	$ 2,310.00	$ 10,419.00
Muc Off Nano Lube (Extrapolated Data)	$ 280.00	70.0	$ 3,500.00	35.0	$ 4,550.00	11.7	$ 2,345.00	$ 10,675.00