

Zero Friction Cycling



Chain Tensile Strength Test Project Brief

Project Objectives;

>Independently tensile test chains to determine;

- As chains have become ever thinner has tensile strength decreased, remained the same, or even increased due to higher material & manufacture quality – So 12 spd vs 11spd vs 10spd vs 9spd.
- Any difference in tensile strength between super light chains with material cut out of plates & hollow pins vs chains with solid plates and solid pins
- Any difference between super cheap, budget, mid level and premium chains.
- Will any manufacturer standout – for better or worse
- Reduction in tensile strength for worn chains vs same chain new
- Relate the tensile test figure results back to the tension load that chains are under during cycling – that part of the project subsequently covered in this document.
- If possible after main chain testing has been completed, look to see who makes most secure connecting link.

Now that we are aware of the main objectives for this testing project, lets dive into one key part, and that is relating the results seen from test machine to something that we can relate too whilst riding around.

To do this we need to convert real world pedalling watts into chain tension in newtons to compare what is happening in real world vs what this test is showing.

Now firstly, I am not an engineer. I am simply an avid cyclist and racer across road, tt, cx and mtb who over the years has put a lot into learning about saving watts, saving running costs, and in starting zfc – wanting to conduct genuine robust testing to determine what products I should stock, and what products I should avoid.

On the surface, it may seem that tensile strength testing may be less likely than other test projects to influence decisions on what ZFC decides to stock and recommend or avoid, but some interesting things have been learnt already just putting this document together, and one thing I know from other test projects – surprises always come up!! Keep reading and you will see recommendation number 1 coming up, and at the time of writing this brief I haven't even started testing proper, just some test runs to bed in operation of machine and software.

Anyway, back to relating test results to something real world cyclists can understand.

Getting a failure number in X thousand newtons is cool, but newtons won't mean much to a lot of cyclists, and while some may understand how much force X newtons equates to, few will have much of an sense of how many newtons of tension their chains are under whilst riding around.

Being able to relate the test results and how much buffer is there between the level of force likely to be generated by amateur and pro level cyclist's vs ultimate failure strength of chain I felt is very important to enable the testing results to be easily understood by readers.

I will outline the calculations sent to me by a very helpful engineer cycling friend, **but there are a few key points to note.** We are converting a **dynamic situation** of pedalling which we measure in watts, and winding it all the way back to **a static tension figure**. This is not easy.

To start with, even for your power meter to give you a watts figure on your cycling computer, a lot is happening.

Power = Torque) x Rotational Speed. As you apply Force through your pedals (measured in Newtons), this applies a Torque or “turning force” into your crank. The Torque applied is a function of both the force on the pedal and the crank length (Torque = Pedal force x Crank length). The combination of this Torque and your cadence or rotational speed is the power you are generating in Watts.

If you kept the same level of force exerted on pedals but doubled your cadence, you would double your power. If you kept the same cadence and wanted to double your power, you would need to double the force exerted into pedal.

But arriving at watt’s figure from your power meter to your cycling computer is not so simple. The amount of force you exert upon your pedal is changing rapidly during the pedal stroke and across a full revolution of the crank. Every full pedal rotation sees variable force being applied to the crank while the pedals are at different points in the rotation. The maximum force is applied when the pedal is in the 2 o’clock to 3 o’clock position, while the lowest force is applied when one pedals is at 12 noon and the other is at the 6 o’clock position.

As such, your power meter is sampling hundreds of times per second exactly how much force is being exerted on the pedals as it moves through a full revolution, combined with how fast the pedal is travelling, and the final watts figure you see on your cycling computer is the average of that complete crank rotation. Depending on your power meter and cycling computer, it may have taken up 512 measurements of the above per second (512hz sample rate), all of which is then calculated out to attain the average force x speed for that crank revolution to deliver you a nice and neat figure in watts of power on your cycling computer.

Understanding that for a given power figure that there are high and low forces applied throughout the stroke is important as this obviously means there are high and low forces applied to the chain during the pedal stroke for a given power output. If we just calculated back chain tension from the average power during the rotation then we would understate the max tension on the chain.

Okay – so for a given power, to transfer this from the chain ring to the cassette, the chain will be under tension force, and the SI unit for tension force is a Newton. A newton of force is a bit over 100 grams – 1 newton of force is about the same force as decent sized apple.

Torque – or turning force – is measured in Newton Meters. This is one newton of force (or one apple) being pressed onto a lever that is 1 meter long.

So if you had a crow bar that was one meter long, held it horizontally at one end and sat a nice big apple on the end of it, that is going to be basically one newton meter of turning force or torque.

Newton meters are often converted into Kilogram Force (Kgf) as it is easier to imagine X kg of weight vs Newtons or an orchids worth of apples. It is not an exact conversion but very roughly 10 Newton meters (or 10 apples on the end of a 1 meter crowbar) is equivalent to 1 kilogram force (kgf) – or sticking a 1kg weight on the end of horizontal 1 meter long crowbar.

A watt is a dynamic measure. 10 watts of energy will lift just over 1 kilogram over a distance of 1 meter in a time of 1 second. So 100 watts will lift approximately 10 kilograms a distance of 1 meter in 1 second, 1000 watts will be able to lift a bit over 100kg 1 meter in 1 second and so on.

Right – now that we have our basic force and power measure units down pat, we need to bring the watts figure you see on your cycling computer all the way back to chain tension in Newtons to compare to the results we see from my tensile strength test machine. To do this and take a dynamic measure and turn it into a static measure, first we have to pick some assumptive values to calculate backwards.

We need;

- A power output
- Chain ring size (chain tension in Newtons = Crank Torque divided by chainring radius, so bigger chain rings for same power = lower tension, smaller chain rings for same power = higher tension).
- Cadence so that we can calculate rotational pedal speed so we can calculate Torque.

Calculating the tension back from there will only work for the given values chosen. If you keep the power the same but change the chain ring size, the tension will change – smaller will increase chain tension, larger will decrease chain tension. Decrease cadence for the same power and tension will increase, increase cadence for the same power and tension will decrease.

To start with, let us use 400w power output, at 100 cadence, with a 53t chainring and 175mm crank length.

Don't worry if the next bit loses you – this is from the engineer and so is for engineer readers, it will all come back to normal person speak soon 😊

Putting out 400 Watts at 100 RPM, they are pedalling at a Rotation Speed of (100 RPM) x (0.1047 rad/sec/RPM) = 10.47 rad/sec, so their Torque = (400 Watts) / (10.47 rad/sec) = 38.20 Nm applied to the cranks.

Crank Torque = Pedal Force x Crank Length

Pedal Force = Crank Torque / Crank Length

Pedal force = 38.2 Nm / 0.175 = 218.3 N.

To convert to a Force at the circumference of the chain ring, you just need to account for the radius of the chain ring. The radius of a 53 chain ring is 107.5mm.

Therefore;

Chain Force = Crank Torque / Chain ring radius

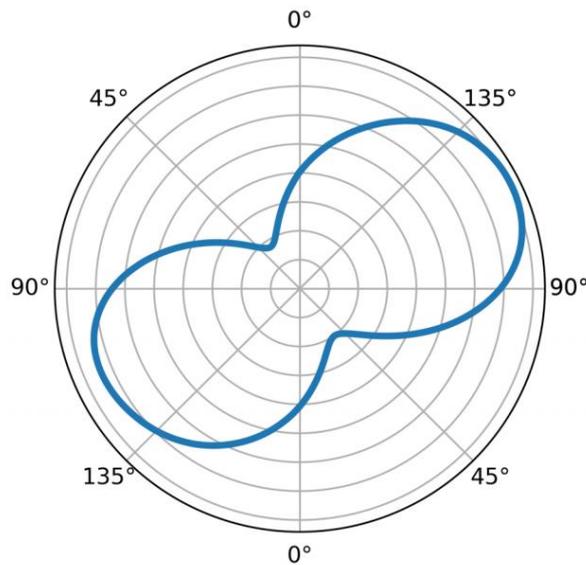
=38.2. Nm / 0.107505m

=355 Newtons

So there is magic figure number one that we need - 355 Newtons of tension. This is the average force experienced during the crank's rotation at 400W, 100rpm, with a 53t chain ring.

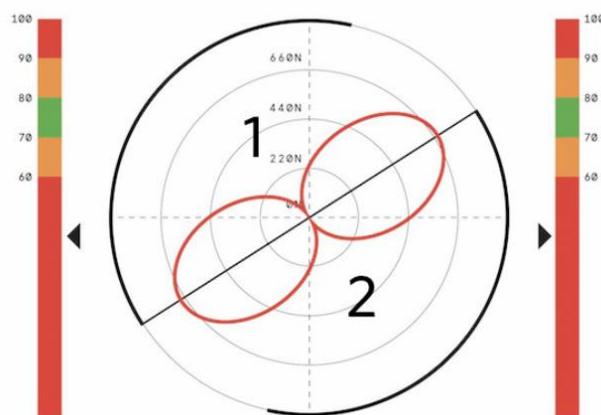
But we know from previous paragraphs that the average force during a revolution is not the peak force as each revolution has dead spots and peak power generation phases within each revolution. Having a look at some data from cycling dynamics it is relatively safe to assume that for many cyclists the force during peak phase can easily be around 150% the average force of a crank rotation. Therefore - for relative assumptive purposes, we can call our 400watts that equals 355 Newtons of tension force average and increase that tension figure to 533N of tension to account for peak tension chain would likely be under during that crank revolution.

Below is a diagram showing what a beautiful pedal stroke would look like if you have pedalling dynamics being measured by your power meter and a most magnificent pedal stroke. In the below example, peak torque (and therefore chain tension) is just over 150% of average torque for 1 crank revolution;



**Diagram above and below sourced from team zwatt – great source of info re cycling dynamics - <https://teamzwatt.com/training/best-way-to-visualize-cycling-dynamics/>.*

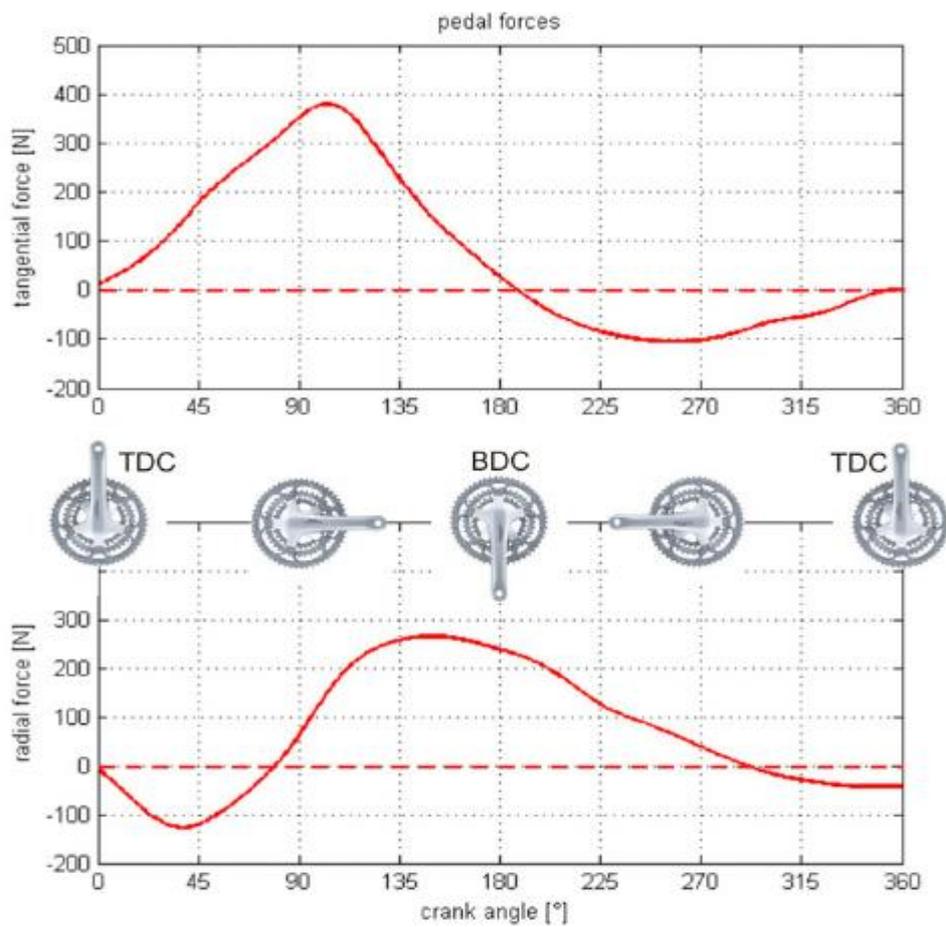
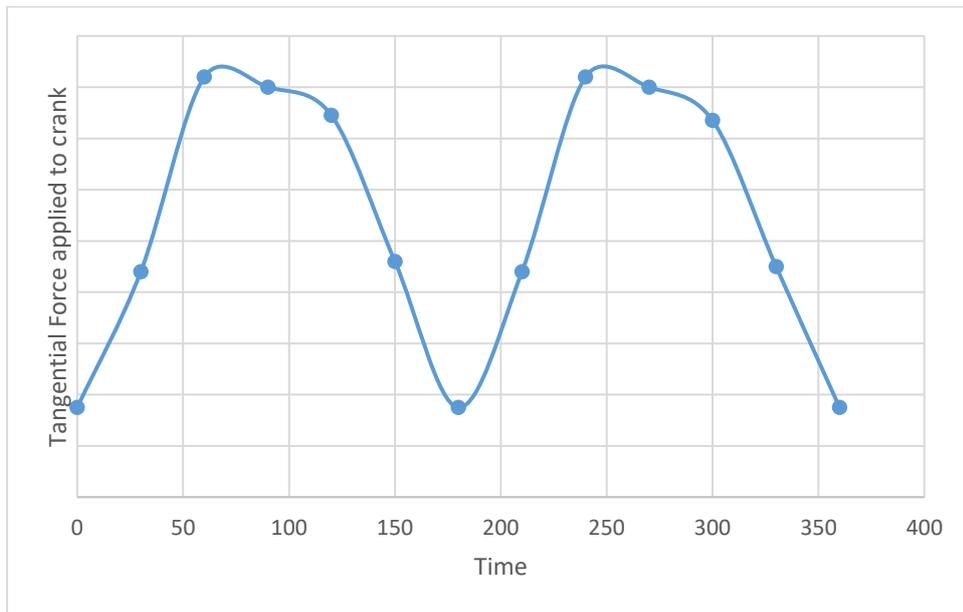
Now what if the cycling dynamics is altered due to say stand up pedalling? A less efficient pedal stroke, or possibly one during a stand up sprint, may look something more like the diagram below, in this example peak torque (and therefore chain tension) is just over 200% of the average torque for 1 crank revolution;



<https://magazine.bikesoup.com/cycling-efficiently-perfecting-pedal-stroke-power>

**Their website certificate has expired so may show as unsafe in browser, a further resource of great info re above can also be found here:*

And here are the charts that form the basis behind the 150% peak vs average torque (and therefore tension) calculation sourced by my handy cycling engineer.



I don't have same charts for stand up sprint pedalling situation, but for assumptive torque & tension purposes it won't be a stretch of the imagination to call it up to around 200% of the average for a crank revolution (as per pedalling dynamics diagram previously with two red ovals depicting torque through 1 crank revolution).

Also, pedal efficiency itself for the same athlete is likely to be quite fluid – it will likely be a completely different profile during a stand up sprint vs pedalling at tempo up a 4% climb sucked along in the draft of a peleton. Pedalling dynamics are almost certainly going to vary to the positive with a good tailwind, and to the negative with a solid headwind.

However, using 150% for peak vs average is a very accurate assumption for a lot of pedalling situations, and 200% would be a very safe assumption for pedalling situations such as stand up sprint, especially when starting from a low cadence.

Extrapolating from the above, we will get some Watts to Newtons of tension tables as per below;

Watts to Peak Newtons & Kgf conversion Table 1 - High pedal stroke efficiency - Peak tension 150% of average tension for 1 revolution			
Watts (53t ring, 175mm crank, 100 cadence)	Newtons of Force - Chain	Kilogram Force (Kgf) Chain	Kilogram Force (Kgf) Pedals
400	533	54	22
600	799	82	33
800	1,066	109	45
1,000	1,332	136	56
1,200	1,599	163	67
1,400	1,865	190	78
1,600	2,132	217	89
1,800	2,398	245	100
2,000	2,665	272	111
2,200	2,931	299	122
2,400	3,198	326	134
2,600	3,464	353	145
2,800	3,731	380	156
3,000	3,997	408	167
Industrial Standard for Chain Tensile Strength = 8000N			
*Based on peak being 150% of average			

So we can see that even when pumping out a solid 400w, we are really only exerting around 533N of tension on a chain that should be rated as a minimum to 8000N which gives us a safety factor of 15. Sit down power it would take quite a specimen to achieve 1000w, which is going to be around 1332N, still giving us a safety factor of 6.

Basically with a good pedal efficiency, a cyclist would need to be approaching 6000w mark to be hitting a chains minimum rated tensile strength.

You can see a line highlighted in red, this is the point where to generate that power how many kilograms of force would be needed on the pedal. From some research it is generally accepted that it is extremely difficult for most to exert greater force than their bodyweight on the pedals, especially during sit down pedalling. So that 100kgf of force on the pedals is a very very safe upper physiological limit likely to be encountered in real world, and honestly in general at a 100 cadence 99% of cyclists are not going to attain anywhere near that number.

However – and this is the big one, we do not yet know what reduction in this tensile strength may be or will be on high chain line angles. There is no standard for this, and there is currently no test for this – although ZFC and engineers are working on adapting machine to test for this – stay tuned.

Based on data that we can calculate and measure – we can see in the above table that there is a very big safety factor with regards to the ultimate tensile strength of the chain vs the tensile force we can exert upon it.

There are conditions that will change the above figures somewhat though;

Let us look at what is likely happening during a stand up sprint, where pedalling efficiency is likely to change dramatically, and move from that beautiful peanut shape example that is the goal of those using cycling dynamics, more towards the two red ovals where peak torque & tension is going to be at least around 200% of the average tension for a crank revolution. This would give us a table that looks like the below;

Watts to Peak Newtons & Kgf conversion			
Table 2 - Poor pedal stroke efficiency - ie stand up sprint			
- Peak Tension 200% of average for 1 revolution			
Watts (53t ring, 175mm crank, 100 cadence)	Newton of Force - Chain	Kilogram Force (Kgf) - Chain	Kilogram Force (Kgf) - Pedals
400	711	72	54
600	1,066	109	82
800	1,421	145	109
1,000	1,777	181	136
1,200	2,132	217	163
1,400	2,487	254	190
1,600	2,842	290	218
1,800	3,198	326	245
2,000	3,553	362	272
2,200	3,908	399	299
2,400	4,264	435	326
2,600	4,619	471	353
2,800	4,974	507	381
3,000	5,330	543	408
Industrial Standard for Chain Tensile Strength = 8000N			

Now we can see that a top amateur sprinter at around 1400w will be approaching 1/3rd of the chains max tensile rating – again remembering that rating is for a straight chain line only. And a huge powerhouse like Marcel Kittel at his best doing 1800 to 2000w MAY be putting chain under a strain of around 40% of what it should be rated to handle in a straight chain line, and a mountain of a track sprinter approaching 2500w for a few seconds COULD be approaching 50% of the chains tensile limit. I say MAY and COULD as remember the above are from calculations based on assumptive figures from pedalling dynamics and peak tensions for a very small fraction of second during pedal stroke.

Where we look at extreme situations such as a track sprinter out of the blocks heaving into pedals we can run some numbers of X watts at very low cadences which show extremely high newtons force exceeding 8000n, however it is important to remember that everyone is limited by just how much pedalling force can be exerted. Even for track starts this is generally limited to around 2x body weight, it becomes very difficult to exceed this, and at the time of writing discussing this project with the head of major cycling company who just happens to be researching chains at the moment (handy timing), he advised that they work on 3x body weight max pedal force as a safety factor but that it is unlikely even a 100kg

rider would be able to exert 300kg of pedal force. That is essentially doing a 300kg one legged squat, needing your arm pulling against handlebar to counteract this force. It is simply unlikely to be possible, even 2x body weight of pedalling force would only be able to be attained likely by extremely few athletes in the world.

Suffice to say, it is likely for most that even a very thin 11spd chain is going to be perfectly capable of handling track loads, however for very powerful sprinters they may be approaching 1/3rd of the chains ultimate tensile strength and the most powerful in the world possibly one half. This is leaving a safety factor of only 2 or 3.

Already you will find that for some pursuit events, and pretty much for all hour record attempts of the last few years, smarter riders / teams are on 11spd chains for their much lower friction vs track chains, although powerful sprinters are obviously hesitant to go down this path....

Upon discussing with very smart industry guy currently researching chains at the time of writing (and until I can test), there is also a bit of contention as to just how much stronger a lot of track chains may be, despite the vastly greater girth and plate + pin thickness.

He advised that top 11spd chains are made of a very high quality steel, and that many track chains which may cost only somewhere between \$10 to \$30 or even \$50 – the steel used is of much lower quality, and of course misses all the low friction coatings of quality 11spd chains, and by design (bushing chain) and size are going to be eating up watts.

This makes sense even from an economics perspective, if you buy twice as much steel for 1/3rd the price, it is highly unlikely that the steel is going to be anywhere near the same quality. It is possible they are attaining same or hopefully greater tensile strength than an 11spd chain, however achieving this simply through sheer weight of metal and at notably higher friction losses, it is perhaps time that for many athletes they start considering switching from track chains and cogs to 11spd chains and cogs. By and large it seems track just follows tradition. Track bikes run big heavy track chains – but do you need these big heavy track chains or is the maximum tension you can exert going to be well under what an 11spd chain is rated to take, and you are just carrying extra weight and losing watts?

I have some data on friction levels for top 1/8th track chains fully race prepped, and they are typically around 2watts higher at 250w load, and therefore circa 8w higher at 1000w load (chain friction increases at around 89% linearity to load based on Friction Facts watts vs load testing), so if you are going to average 300w, 400w, 500w etc for your effort, there are a few

free watts to be gained. It is just very entrenched in track that you run 1/8th chains, and so rings and cogs are 1/8th, and no one thinks twice about it.

However – the proof will be in the testing pudding. Until I have couplings made for track chains and start testing track chains I would say at this stage powerful track sprinters stay with a QUALITY (not cheap) track chain, and that less powerful sprinters, pursuit, Maddison, hour – time to go lighter and faster.

Right, segue over, let us quickly look at what may be happening in the offroad world where small rings and high power high torque situations often arise and mtb events frequently have short steep ramps to power up.

It is important to remember that the above tables are assuming a cadence of 100 rpm and with a chain ring size of 53t. For the above power figures. If the same power was being produced, but the cadence halved, then the tensions in the above tables would double (*assuming no change to pedalling dynamics). If the chain ring size was much smaller, the tension would also increase relative to the reduction in radius, so all of sudden a situation like a Mountain bike rider smashing up a 25% ramp in a 32t chainring at 50 cadence – we can see how quite commonly very high tensions can be placed upon chain in this type of riding.

Below on this scenario is the table below;

Watts to Peak Newtons & Kgf conversion			
Table 3 - Mtb - Steep ramp, 32t ring, 50 cadence - Peak tension 175% peak vs Avg due to impacted pedalling dynamics			
Watts (32t ring, 175mm crank, 50 cadence)	Newtons of Force - Chain	Kilogram Force (Kgf) Chain	Kilogram Force (Kgf) Pedals
400	955	97	45
600	1,432	146	67
800	1,910	195	89
1,000	2,387	243	111
1,200	2,865	292	134
1,400	3,342	341	156
1,600	3,820	390	178
1,800	4,297	438	200
2,000	4,775	487	223
2,200	5,252	536	245
2,400	5,730	584	267
2,600	6,207	633	290
2,800	6,685	682	312
3,000	7,162	730	334
Industrial Standard for Chain Tensile Strength = 8000N			

It is certainly not uncommon for elite mtb riders to pump out circa 800w at low cadence to smash over a steep ramp, especially on early short ramps during an XC race. This will have tension around 1900 Newtons, and likely on a notable chain line angle – for which we as yet just do not know how much this reduces the tensile strength rating from 8000N. There will still be plenty of buffer, I race mtb as much as I can and I have never seen a chain snap yet from anyone on a power climb, however I do know it happens. There will not be straight $8000/1900 = 4.2$ safety margin. Maybe it will only be a factor of 3, or even 2, depending on chain line and just how hard an elite hits the climb and at what cadence.

Again you can see red line which would denote the likely maximum pedal kgf likely to be possible to be exerted and therefore the likely max possible chain tension.

Safety buffer, Stress Cycles, and why chains break.

As I complete testing across many many chains from super cheap to premium, solid plates to lightweight with heavily cut out plates, and 12spd down to 9spd, and also track chains - it will be very interesting to see what the numbers come out. It is quite possible that all chains across all speeds test above International standard of 8000N, and some above German standard of 9200 Newtons. It is possible that pretty much all 9spd to 12spd chains and even most track chains come out between say 8000 and 10,000 Newtons.

So the question is – should be concern ourselves if a chain is just over the international standard of 8000n or attains a very impressive 9000+ or even 10,000+?

Considering that for most of us, attaining chain tensions of around 1000 to 1500N is going to be probably the maximum tension stress we will ever be able to exert into our chains, even 8000N is a decently sized safety buffer. On the surface, a chain that tests at 9000 Newtons vs the 8000 newton international standard is a chain that can handle at least around 600w more power in stand up sprint watts – but it is key to remember we are simply never going to be remotely near that territory.

Without doubt – bicycle chains break, and I personally believe bicycle chains break more often than would be acceptable in any industrial application (think of cam chains in vehicle engine, production line conveyers etc).

Why is this so when there is a likely safety factor of 4 to 5 times?

The most likely theory at this stage pending further information is simply manufacturer error rate. If there has been a problem with the metallurgical process of the link plates, or a poor pin rivet – at this one link the tensile strength may be greatly reduced to a point where it may easily fail.

Sans manufacturer error, really maybe the top 1% of the most powerful cyclists in the world will be putting chain under strain that reduces safety factors down to maybe only 3 vs 5+. Again we are limited by just how many gravities of torque force we put into the pedal and therefore into the chain.

But – and this is where some of the test data may be useful for this very small percentage of riders, the more safety factor one has, the more likely it is the chain will not fail.

If due to a manufacturing error the chain does not have 8000n tensile strength but only 2000n, then a rider who may be able to surpass this limit will be able to snap chain during a maximum high torque burst.

Stress Cycles - Some other research reading revealed chains, being made of steel, do have a fatigue limit strength. Therefore over time, there are a finite number of stress cycles a chain link can experience before failure. The greater the % of the chains ultimate tensile strength per stress cycle the links are subjected to, the lower the number of cycles that can be experience before failure. The lower the %, the greater number of cycles. This particular article was looking at industrial application, however the same would apply for cycling.

For industrial application, they recommended a “fatigue strength” use limit of around 15 to 20% of the ultimate tensile strength of the chain. This will ensure chain reaches recommended wear replacement mark prior to getting near its fatigue limit, and as such recommended a safety factor of 5 to 7 (again think of car engines camshaft chain etc, where failure of that chain would lead to destruction of the entire engine).

We can see in cycling that even strong recreational riders will be attaining tensile forces that can approach a safety factor of 5, or even 4, and elite track riders / sprinters possibly even 3.

But for cycling application we have a bit of a paradox. We can see there are times where it is possible the tensile forces may be greater than recommended safety factor of 5 to 7 – and that is before we factor in chain line angles which are not encountered in industrial applications, but on the other side much of our riding for most cyclists is going to be between 150 to 250w. 200w is going to be around 300n max depending on pedalling dynamics, which even for the minimum 8000n is a safety factor of around 27.

So we can see that in cycling despite our very thin chains, even with chain line angles which may impact ultimate tensile strength by an as yet unknown amount – the majority of the time we are going to be cycling around with a huge safety factor, however for some short bursts and sprints there may be times when we exceed normal industry safety factors.

It is at these moments when any manufacturer fault will be highlighted that has led to a reduction in the ultimate tensile strength – especially in a more worn chain that has undergone millions of stress cycles.

A light to medium weight rider who doesn't do sprint efforts but just trains within a fairly normal power range may never expose this fault as never approach the tension required to cause failure in a chain that has a weak link. But, a more powerful rider who trains high intensity intervals and sprints as well as performs shifts under high load just may.

It is a fact - chains break – and based on their tensile strength rating, they simply should not.

What I do know is that in general we can class our bicycles as a “race weight” machine. It is human powered and we have very little sustainable power vs engines. For many we really only have an average power of around 150w to 250w for most of our rides, which is 0.15 to 0.25kw. This is pretty tiny vs what most machines will be pumping out.

The bearings on your passenger car will typically last 300,000 to 500,000km without servicing. If there was a demand for it and so manufacturers had a reason to produce, you could also have wheel and bottom bracket bearings last 300,000 to 500,000km. After all they are under vastly lower loads than your car bearings. But by golly they would soak up some watts, it would feel like you were riding with the brakes on.

Similarly, you don't typically replace your car tires every 5000km. Or the gear box (in place of chain rings and cassette) every 10,000km ish.

If your car went through the component equivalent at the same rate as your wear them out on your bike, it would be quite a scandal.

A v8 supercar receives somewhat more maintenance and attention than your passenger car. They do not use the same bearings, as friction savings are important. Your bicycle isn't a v8 supercar, however the majority of the parts you can definitely class as being very much in the “race” end of the spectrum with regards to their general lifespan and ultimate strengths – even if it is your intrepid commuter - because they are human powered and even 10w extra friction or not or 1kg of extra weight or not is quite noticeable with our limited power.

Hence why exploring the tensile strength limits of our comparatively short lived, very thin, very hard working, and in certain situations a much lower safety factor than would be accepted in industry - is of curiosity to this nerdy focussed cyclist here at ZFC, and the launch of this fun side project.

Chain line angles and reduction in tensile strength?

In the brief above it has been mentioned a number of times that chain line angle may reduce a chain's ultimate tensile strength, but note this is a possible theory only. It is entirely possible it will have zero or very little impact.

Derailleur chains are designed to run on chain line angles.

Initially I had hoped to kick off the test project with two sets of couplings, one set tests for straight pull, and second set that introduces chain line angle of around 5 degrees which is typical of big ring / big cog cross chain situation which the most extreme chain line angle most chains will experience.

Initial test runs to bed in operation of the machine and software has shown a couple of interesting pieces of information already.

Firstly, by far the most common failure mode in the straight pull testing is outer plate being pulled off pin rivet due to elongation of the hole in the outer plate. This negates the riveting of the pin anyway allowing the plate to burst off pin as the hole is not too big for the pin rivet. On average this has been occurring at around 9000n.

The couplings that introduced chain line angles had the cog teeth bend and fail prior to the chain failing, so the newtons of force required to cause pin rivet fail is looking to be pretty enormous, pretty much in line with straight pull tension fail figures. The cog teeth were failing at around 7000n.

This is an initial indication that the ultimate tensile strength of bicycle chain may not be overly impacted if at all by chain line angles experienced in cycling. I have had 3 chain failures reported to me in the last 3 years from chains I have sold (current failure rate of 0.2% vs chains sold), and all 3 have had a link plate snap, none have suffered riveting failure.

So I will be merrily breaking chains with straight pull couplings, but note early days testing is currently NOT showing immediate evidence that ultimate tensile strength of a derailleur chain is impacted by chain line angles. It may, and we will work on couplings to definitively ascertain, however I expect from initial testing that even if there is a reduction, it will be relatively small, ie a chain is not going to go from 9000n straight line tensile strength to 6000n when running big ring big cog. My expectation from testing runs so far is that any reduction in ultimate tensile strength will be quite small if any. It is possible during this

testing that we may find a manufacturer who has a particularly poor riveting technique and that an angled test would highlight this when compared to its straight line test, but at the moment there is just no evidence to support this. I will keep on working with engineer and fabricator with regards to couplings that do not fail before chain when on a 5dg angle, but at time of writing this brief, derailleur chains are looking very impressive with regards to tensile strength not being unduly impacted by chain line angles.

All will be revealed over the next approx. 12 months as ZFC works its way through destroying many chains – keep an eye on web page for updated graphs (initial test graphs will start popping up soon). I am quite keen to see if the newer very thin 12spd chains perform similarly their wider girth previous generations, and also how do cheaper but heavier track chains fair vs very thin derailleur chains, we will be able to answer some questions more definitively re strength required vs extra friction which may help some track riders decisions. Just because it is entrenched in track that you run a 1/8th chain doesn't necessarily mean you need too or should – we shall see but it is quite possible you can save a stack of watts running something much lighter and lower friction that will still be plenty strong enough.

Do you snap chains?!

Have you personally had a history of snapping chains? If so please contact me at info@zerofrictioncycling.com.au – let me know what brand/s, when tended to snap, still happening etc etc. Even though the information will be anecdotal, if I get sufficient independent anecdotal information this can sometimes point towards an area of interest worth investigating.

Thanks for reading test brief if you took the time, hope you enjoyed, and hope you enjoy the test project as I work my way through breaking many chains of the next year or so 😊

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Some initial test machine vs real world failure pics;

Pic below is what is occurring with vast majority of initial test failures as bedding in machine and software operation. We can see that despite being a straight pull, the outer plates are bursting off rivets due to elongation of hole in outer plate at pin insertion. So it is failing at the rivets even though it is a straight pull. Due to elongation of outer plate hole, this makes it impossible for pin rivets to retain plate. The tensile force required to cause this has been very high (over 8500n). This places high confidence in the strength of derailleur chain riveting for running chain line angles without a notable compromise in ultimate tensile strength.



Below is a real world failure – Snap through an outer plate link vs rivet failure – this points to a manufacturer error of which there is a % for all manufacturers.



Failure example 2 – snap at plate vs rivet; KMC.



Real world failure 3 – From a rider who advised snaps on average 3 chains per year at low km's – this one was most recent just the day before finishing this brief at the weekends cx round. Again in theory due to tensile strength rating vs possible output, this should be impossible....



Chain line testing - Cog Failure at around 7000n with 5dg chain line angle test coupling - machine test. Work in progress on this front ☺

