Shock-Frame Interface Design: Best Practices for Frame Manufacturers

Rev B
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Shock Mounting Overview

Suspension frames interact with the shock in complex ways - not just by pushing the shock along its axis like it first appears in CAD. Over a decade of servicing, repairing and tuning suspension has demonstrated to us that some frame design concepts and shock mounting systems are unambiguously much harder on the shock than they need to be.

Furthermore, from our discussions with frame designers and test laboratories, it is clear to us that there is a disconnect between frame manufacturers and the shock manufacturers, as usually when there's a shock failure it falls on the shock manufacturer or a service centre to repair - and often the frame manufacturer involved never even hears about the shock failure(s), keeping the designers more or less in the dark about the root cause of the issue, through no real fault of their own.

As a result, in 2024 we are still seeing shock failure modes in the broader MTB market across frame brands AND across shock brands, some modes of which have been occurring for well over ten years without being fully resolved. This indicates that it's not a problem that is the fault of a single entity, but rather, a problem that arises from a lack of clear communication and standardization industry-wide

To help resolve this problem permanently, we've put together a guide for design best practices for the frame-shock interfaces, which are applicable to all shocks. As well as this, we've included our specific compatibility information for the Telum.

Please note that these recommendations come from the desire and intention to improve overall, integrated bike design moving forwards, not to point fingers, beat our chests, pass the buck, or needlessly deride existing designs.

General shock interface - best practices

1. **Wherever possible, use standard eyelet shock mounts rather than trunnion or yoke mounts.** Standard eyelets place far lower stress on the shock by greatly reducing eccentric (non-axial) loads, often called side loading.

2. **Specify reducer hardware with an 8mm ID and a steel through-bolt.**
    a. 10mm can work ok too if you are using aluminum for the frame or rocker link, but can cause problems in carbon due to digging into the frame. It allows a stronger bolt, but at the expense of a weaker reducer pin.
    b. 6mm is straight up garbage, don't use it unless it's to save the planet like Bruce Willis in Armageddon.

3. **Specify reducer hardware widths in a round 5mm increment.**
    a. 30mm is our recommendation for width, as it is common (riders can easily find hardware for it), a nice round number, happens to fit a couple of other brands' bearing mounts and provides good clearance around the eyelet without being so long that it is prone to bending shock bolts. There is not a lot to criticize about this.
    b. Wider than 30mm is generally unnecessary unless a swingarm or link needs to pass either side of the seat tube, but even in such a case, width should be minimized if that needs to happen.
    c. We generally recommend a minimum of 20mm in width too. This is because it allows enough space for the reducer spacers to be installed on the pin, without worrying about fumbling tiny little disc spacers during installation.
    d. This means that there are really only three reducer hardware widths most frames should be using - these are 20mm, 25mm and 30mm.
    e. If using a yoke, the yoke should clamp directly to the eyelet, and any reducer hardware used should be made undersize for the 12.70mm nominal width eyelet (width, not diameter) to ensure that the eyelet is clamped by the yoke.

4. **Frame mount tolerances should be an easy clearance fit from nominal size**, for example -0.00mm, +0.20mm at the shock mounts in order for the hardware to fit in snugly and be able to tighten down properly. Exactly what tolerance you need to use will depend on how much the frame's mounts can move once clamped (see next point)

5. **The frame's shock mounts need to be able to squeeze inwards at least 1.00mm in at a torque of no more than 20Nm**.
    Be very wary of making these mounts too short and/or stiff (this is easy to do around the bottom bracket area) as it will prevent the frame grabbing the hardware tightly, and you will get play between the shock hardware and the frame. You want as much of the bolt torque as possible to be clamping the reducer pin rather than just stressing the frame

material. This reduces the likelihood of the bolt coming loose, reduces stress on the frame and reduces fatigue stress on the bolt.

6. **Ensure that both ends of the shock have at least 15mm radial clearance** in all directions from the centre of the pin (ie around the eyelet). This is partly to ensure clearance with the eyelet, and partly to ensure that the shock mounts are not too stiff in bending (see above).

7. **Ensure that the radius of the frame material around the shock bolt holes (at the frame-shock mounts) does not exceed 10mm**.
   With a 10mm or 8mm diameter shock bolt, this allows you 5mm or 6mm respectively of material around the bolt hole. If this is insufficient, consider using Haloumi or some other stronger grade of cheese for the frame.

8. **Do not use single-shear bolts under bending loads unless absolutely necessary.** These see much higher stresses than double-shear (ie through-bolt) type loads, and are more prone to coming loose and/or breaking, because as soon as they come loose, the bending stresses go through the roof. Through-bolts (double shear) are much stronger and have greater tolerance to load when loose.

9. **Remember that with enough force, any shock can be extended further than its nominal eye to eye length -** assume that's by as much as 3mm. Ensure that your frame won't foul on itself if this happens.

10. **Remember that things flex under heavy bottom outs (both frame and shock)**.
    Ensure you've left clearance. Assume the shock can effectively overtravel at least 3mm beyond its nominal bottomed out length.

11. **Remember that your frame is only ever dead straight in one situation: in CAD.**
    Everywhere else, at every other moment, it's misaligned by some amount, whether a little or a lot.

Yoke design - best practices

1. **Don’t use them at all if possible**. We understand however that there are competing concerns here when it comes to frame design and that, as someone who designs frames rather than rebuilds damaged shocks, you’ve got a lot to consider besides shock durability. However, point blank: **yokes are hard on shocks**.

2. **Keep the yokes as short as possible if they must be used -** the one pictured above is needlessly long and could realistically be half that length to clear the seat tube. **Shorter is unequivocally better for shock durability**. This is especially important on e-bikes where heavier bike/rider combinations are consistently traveling at higher speeds even on flat ground and climbs.

3. **Ensure rolling element bearings are used in the yoke’s pivots**. Deep groove ball bearings, roller bearings, some Indiana Jones rolling rocks, whatever - but not bushings/plain bearings. They just add to the buckling tendency.

4. **Ensure the yoke is generally stiff in bending in the vertical plane of the bike**, as this is the plane in which buckling occurs, which causes huge side loading on the shock. The term “side loading” here doesn’t mean horizontal loading, it means anything that isn’t coaxial with the shock’s designed axis.

5. **Ensure the yoke has good purchase on the eyelet of the shock** in order to maintain coaxiality - the one pictured above does this well.
6. **Don't combine them with trunnion mounts**. Yokes exist to lengthen the shock, the trunnion mounts are there to shorten it. However, the yoke-to-shock-eyelet interface is substantially less rigid than the shock itself, and so shortening the shock's eye to eye length AND lengthening the yoke moves the weakest interface closest to the centre (the highest stressed point) of the shock column, especially when the shock is at or near bottom-out.

7. **Don't rely on clamping on conventional reducer hardware with the yoke.** This is truly terrible in many ways:
    a. Reducer hardware necessarily has axial play. This introduces non-coaxiality conditions immediately.
    b. Standard DU and IGUS type eyelet bushings are not stiff enough in bending to keep the axis of the yoke aligned with the axis of the shock once it wants to bend. More side load is more bad.

8. **Why yoke length matters:**
   Buckling has been well understood for nearly 300 years. Euler's critical (buckling) load (https://en.wikipedia.org/wiki/Euler%27s_critical_load) is inversely proportional to the SQUARE of the length of a column - the column being, in this case, the shock and clevis assembly, and the length being its total eye to eye length.

   When a shock is compressed, its bending stiffness resists the tendency to buckle, but the bending stiffness of the shock is greatly reduced by both the increase in overall length AND the low stiffness of the yoke-to-shock interface. Under buckling, the highest bending moment occurs halfway between the two end eyes, and as the yoke gets longer, not only does the peak bending moment increase, but this low-rigidity interface between yoke/eyelet/shaft gets closer to the point with the highest bending moment, further inducing critical buckling failure.

9. **"Doesn't this mean you just need to build the shock to be tougher? Air shocks can handle it right?"**
   Yes and no. A bike is an integrated vehicle, where frame and shock need to work in harmony. Air shocks are also under much higher stress if using a yoke, and this demands higher friction from both bushings and seals to avoid burping air. One can make any shock strong enough to handle whatever loads you want to put on it if you don't care about weight, size, friction and cost - that's what a MacPherson strut is (or a telescopic fork for that matter). However, if your goal as a frame designer is to build the best performing vehicle, with minimum weight/cost and maximum reliability, then you should pay attention to designing the frame so that it minimizes unnecessary loads on the things it is responsible for passing loads to.

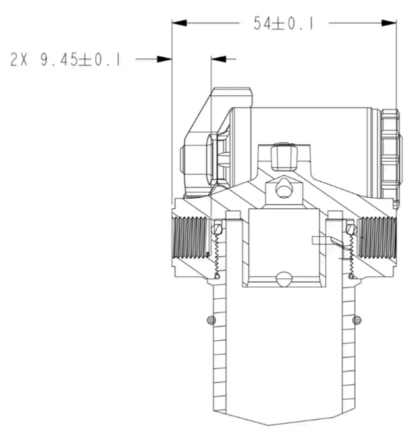
Trunnion design - best practices

1. **Don't use a trunnion mount if it can be avoided**. Standard eyelets are much easier on the shock as they are much more tolerant of misalignment. However, trunnion mounts allow you to use bearings in the frame/rocker arm (good for friction & durability) and they shorten the shock length by 25mm - a packaging advantage particularly for e-bikes using a vertically mounted shock.

2. **If you must use trunnion, ensure the shock is not subjected to significant side loading** due to static misalignment or dynamic misalignment (frame flex due to side loads). The shock is intended to be a "two force member", meaning that it is only intended to generate force directly along its axis. They aren't intended to be a structural part of the frame that can help withstand side loads.

3. **Keep the trunnion mount bearing-to-shock spacers/washers as narrow as possible -** ie minimize the inside width between the bearings in the rocker arm or frame to be as close to the 54mm standard as practical. Trunnion and its single-shear aluminum bolts are already suboptimal for strength; increasing the bending moment on the bolt by increasing the spacer width beyond the minimum necessary for clearance is bad practice.

4. **Ensure the trunnion bolts are sufficiently strong and the correct length**. There should be sufficient thread engagement and you should avoid hollowing them out completely. Also ensure the bolts are not too long, as if they contact the bottom of the hole/thread they will cause the head to crack and leak. Bolts must not be more than 9.20mm long (total intrusion into shock from 53.90mm LMC width of shock head) and should not have more than 8.20mm intrusion at full thread profile. See below for the de facto trunnion mount specification from Rockshox. Note that it is impossible to have a full thread form closer than 1.2mm from the bottom of the 9.35-9.55mm deep bore.



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5. **Trunnion bolts should have sufficient torque and a medium (eg Loctite 243) threadlocker specification** to avoid loosening under use, but retain the ability to be removed when required.

6. **Ensure that the static alignment of the frame is within +/-0.5mm** between the two shock mounts.

7. **Ensure that the frame is laterally stiff enough, OR that the shock is sufficiently isolated from frame flex.** The dynamic misalignment of the frame needs to remain within +/-4mm between the two shock mounts with a 1000N lateral load applied at the contact patch of the rear wheel.

8. If you find yourself combining a trunnion (to shorten the shock) with a yoke (to lengthen the shock), put down the bong and start again when you're sober.

Standard eyelet - best practices

1. **Use these wherever possible** rather than trunnion or yoke mounts.

2. **In cases where the eyelet sees eyelet high rotation, consider building bearings into the link driving the shock**, which still permit a full length pin through both bearings in double shear. The pin can be stepped and used with asymmetrical metric bearing sizes (for example, if trying to avoid using ½" ID bearings, which are not easy to find everywhere in the world) but should ideally still be 12.705-12.725mm where it passes through the shock. (Note: this is an oversize/interference pin tolerance typically required for eyelet bushings, but does not work well for ½" nominal ID bearings).

   This then permits the use of spherical bearings or DU bushings which can be press-fit to the shaft with zero play, and which tolerate axial misalignment better than mounting ball bearings to the shock eyelet. This allows bigger, more robust bearings than can otherwise be attached to the shock.

3. **Don't "invent" some new shock hardware width or specification**.
   Nobody needs or wants that, it's dumb and pointless. Use an existing size, ideally 30mm wide and 8mm ID.

4. **Be aware that the unstandardized-but-de-facto-standard ½" ID eyelet bushing is not built for a nominal or actual 15.00mm ID housing** - the nominal size is 19/32" (what a nice, round number, where you can definitely tell whether it's bigger or smaller than 37/69", thanks to the intuitive genius of the imperial system) which when converted back to sanity is 15.08mm nominal. Tolerance range notwithstanding, this is a LOOSE clearance fit on a 15.00mm-h7 shaft. As a result, shock eyelets are considerably bigger than 15.00mm.

   But, even better, they're not even 15.08mm either, since as mentioned above, the relatively soft plain bearings (bushings) used in bike suspension do necessarily have some tolerance of misalignment, which means a lack of rigidity, and in order to have zero play even with an oversized pin, they need to be a small amount undersize from "nominal". Thanks to the circular reference that the bike industry has created here, there is no nominal size from which reasonable tolerance references can be made, because we all now rely on interference fits where both the housing AND the pin are oversize, not quite using imperial nominal dimensions and not quite using metric nominal dimensions, but instead mixing ½" with 15mm to create the most fun anyone has ever had.

   This can lead to serious problems when using yokes, especially if they clamp on the reducer not directly on the eyelet, because there ends up being several low-rigidity interfaces in series.

Telum-Specific Information

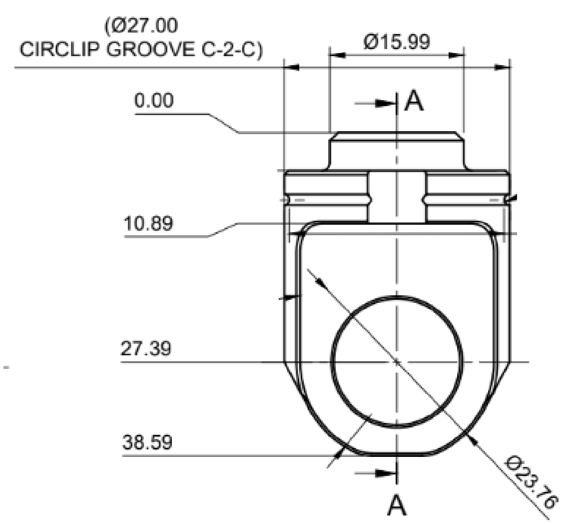
Strut/yoke/clevis mounts

1. Total eye to eye length of the shock including yoke **must not** exceed 315mm for standard eyelet shocks and 290mm for trunnion mount shocks. That means for a 230mm eye-to-eye standard eyelet or 205mm eye to eye trunnion shock, you have 85mm of allowable yoke length. If the yoke is longer than that, the shock is not compatible because the frame may break the shaft. We accept no responsibility for injury, death, inconvenience, frame damage or any other negative consequence whatsoever that occurs as a result of shock failure when too long of a yoke is used.

2. **Any yoke used should use rolling element bearings at its pivot** and not plain bearings/bushings. Use of bushings can cause rotational binding that adds even more buckling load on the shock's shaft/eyelet interface. Without yokes, the total buckling load caused by eyelet bushings can be easily tolerated by the shock because there is very little misalignment moment arm between pivot center and shaft axis.

3. **Yokes should directly clamp on the shock eyelet itself**. Yoke mounts that clamp onto shock eyelet reducer hardware that is wider than the eyelet, instead of the eyelet itself, place dangerous loads on the shock because they do not ensure proper axial alignment of the yoke with the axis of the shock. Eyelet bushings are not built with the necessary rigidity to oppose bending loads, in fact they are highly tolerant of misalignment - which in this case is a bad thing.

4. **Yokes must permit eyelet dimensions as follows:**



Trunnion mounts

The primary difficulty with trunnion mounts for shocks is that the out-of-rotating-plane rigidity of the 54mm mount is very high - however this is manageable if both static and dynamic alignments of the frame's shock mounts stay within what the shock can tolerate:

1. With the shock **laterally unconstrained at the non-trunnion end,** and,
2. With no eyelet bushing installed (ie no friction to resist sideways motion of the eyelet),
3. Under a lateral load of 1000N at a point representing the contact patch of the rear wheel,
4. The shock or a dummy measuring fixture should not displace by more than 4mm at the eyelet end at any point in the travel of the frame.

5. Furthermore, the frame's static alignment should be within 0.50mm between trunnion mount and eyelet mount end. This needs to be checked with a jig tool that can bolt into the trunnion mount and have the distance measured from the frame mounts at the eyelet end of the shock.

Email us for more information if required.

Standard eyelet mounts

Ensure that both ends of the shock have at least 15mm radial clearance in all directions from the center of the pin (ie around the eyelet). This is partly to ensure clearance with the eyelet, and partly to ensure that the shock mounts are not too stiff in bending (see above).

Ensure that the radius of the material around the shock bolt holes (at the frame-shock mounts) does not exceed 10mm. With a 10mm or 8mm diameter shock bolt, this allows you 5mm or 6mm respectively of material around the bolt hole.