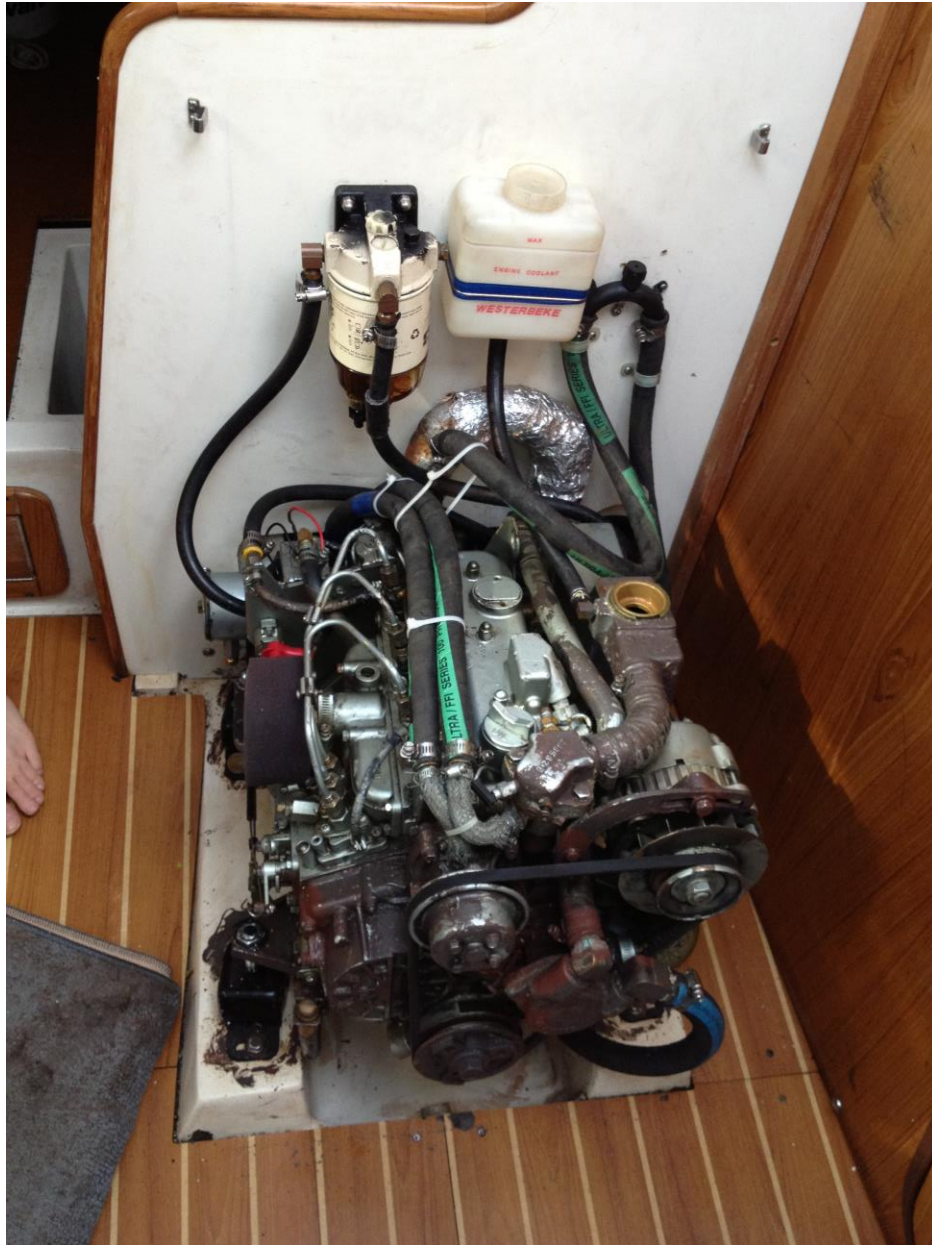


So the job is finally done. New transmission, damper plate and engine mounts. Not a job for the faint of heart. Here is assembled engine front and rear: (my son's foot at the left)





Shakedown runs completed. Everything seems good. Some observations:

- 1) Engine/mount resonance at 800-900 rpm same as always. Thought maybe new engine mounts might affect this, but no.
- 2) Shaft runout (side-to-side vibration) under load looks to be about $1/16$ ". can't remember what this was before job, but seems ok.
- 3) Needed to reset packing gland to get good drip... the gland is on a new (unpolished) section of the shaft, so this makes sense.

- 4) Motored for a couple hrs. Overall operation seemed about as smooth and quiet as I remember when the boat was new. The chatter that was evident with only new transmission but old damper was gone.
- 5) No detectable backlash ("play") in the shaft when in gear with motor off.

So.. I am tentatively calling the job a success. Here's hoping I get at least another 12 years, at which time my son will have replaced me as skipper.

The long story follows:

Here is the engine hanging from the come-a-long (2nd time.. has new tranny but old damper):



Note the steel plate bolted to the underside of the 4x4:



This was strictly to alleviate my paranoia about what would happen if the beam failed, especially if my hands were underneath the engine at the time. The beam fits nicely between the winches and the clutches.

Here is the transmission/shaft coupler before re-attach. It isn't quite adjusted here. The outside edges of the flanges need to be coincident with each other. Horizontal corrections are done by moving the engine laterally on its mounts (not easy) and vertical corrections are done by moving all four leveling screws on the engine mounts (not too difficult). The flange faces need to be parallel to each other. This is done by differential adjustments (twisting the engine and rotating the engine leveling screws). The spec is $<.003$ " difference spacing around the flange face. If the engine mounts are not changed, the process is simpler, involving only the leveling screws.



A word about tools: you will need a good supply of metric wrenches:

- 1) 24 mm socket (I used $\frac{1}{2}$ " drive with short and long extensions), also open end, and also and open end with a built in ratchet on one side. I also cut a 24 mm open end for the port side rear engine leveling screws:



- 2) 17 mm socket (I used both $\frac{1}{2}$ " and $\frac{3}{8}$ " drives with extensions) also open end wrench.
- 3) 14 mm socket ($\frac{3}{8}$ ") and open end.
- 4) $\frac{3}{16}$ " Allen head for the damper plate

Some other smaller wrenches for linkages etc.

I found that the port side forward engine mount (top locking nut) could ONLY be turned with the 24 mm socket and long extension, and even then I found some interference with an oil line.

The hardest bolts to undo were the bolts on the coupler. They are in a nasty environment and get plenty of rust and dirt. I was able to do it with two opposing wrenches and lots of torque, but I could easily imagine resorting to a grinding tool. A torch would probably also work but would make me nervous.

A close second were the $\frac{1}{4}$ " cap screws holding the damper plate. They are held in with Loctite (the red variety, which is high strength) and it takes a lot of torque to break the Loctite. Here are the screws after removal and you can see the Loctite.



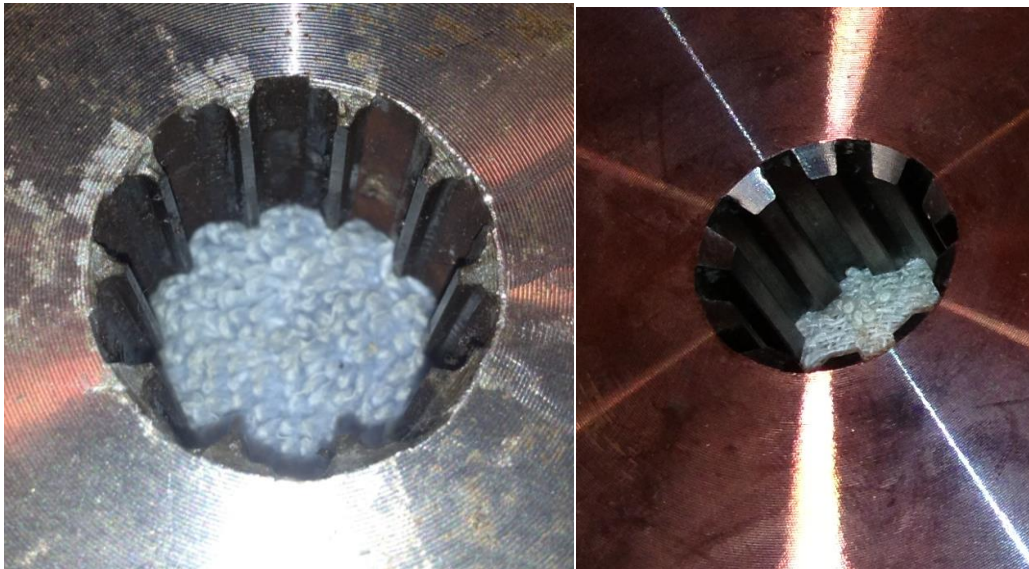
Be sure to use the red Loctite on reassembly. You can buy this stuff at Home Depot.

So I did removal and replacement of the transmission before I realized, from comments on this website and from my Westerbeke mechanic friend, that this is plain stupid without replacing the damper plate. I then redid the whole job, this time replacing the damper. I would certainly second this for anyone considering this job.. do not even think about changing the tranny without changing the damper. The problems I experienced were almost surely due to the failure of the interface between the transmission spline shaft and the spline socket in the damper., with most of the wear damage on the damper side.

Here is the old and new spline shafts on the transmissions:



Here are the old and new spline collars on the dampers;



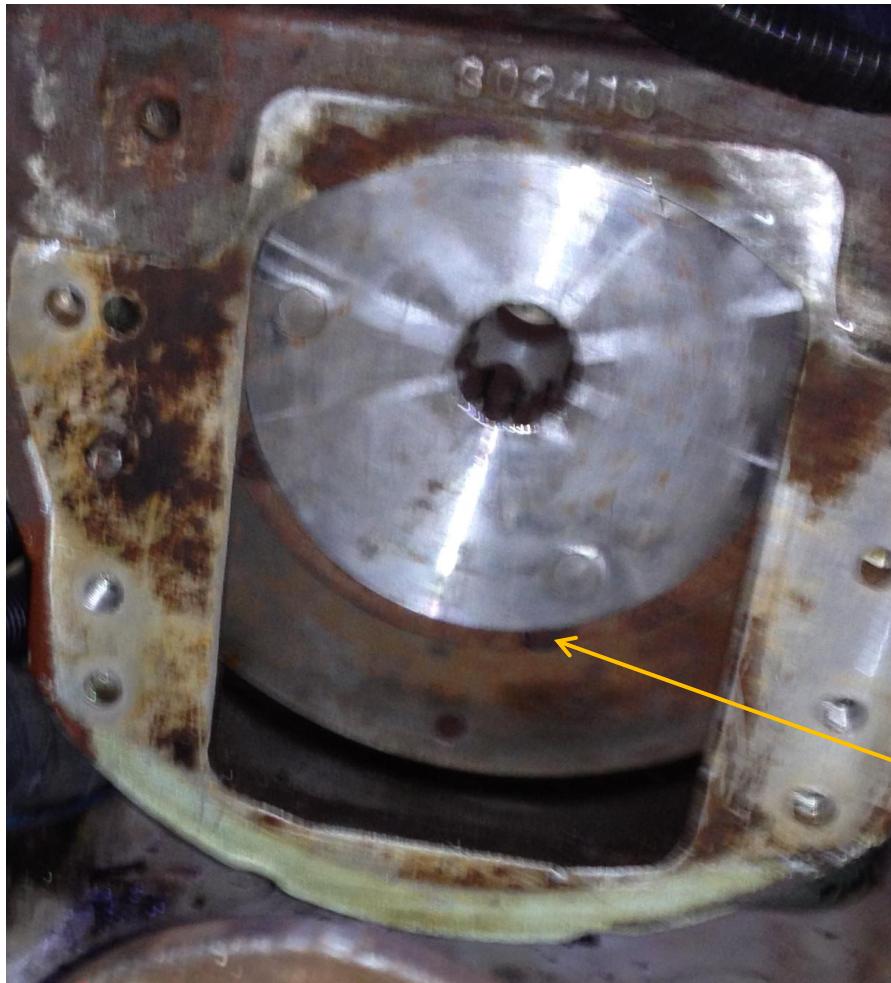
The old spline collar has lost about 70% of its metal. It was all in the bottom of the bell housing as powdered steel.

As you can see there are 10 teeth and ten slots in the spline, so each tooth is $1/20^{\text{th}}$ of a circle or 18 degrees of rotation. The worn spline collar shows at least $\frac{1}{2}$ worn away, which would introduce about 9 degrees of backlash (the transmission should have virtually no backlash). This can be felt as torsional

“play” in the shaft, if you rotate the shaft with the tranny in gear and the motor off. This is a simple test that will tell you if you need this repair. With a good spline you should feel virtually no backlash. If you want to get real scientific you can construct a paper gauge with radial lines a couple degrees apart, attach it to the packing gland nut, and attach some sort of needle pointer to the shaft. You could then measure the backlash pretty easily. I would say that anything more than 2 or 3 degrees indicates significant wear and anything greater than 7 or 8 degrees means imminent failure.

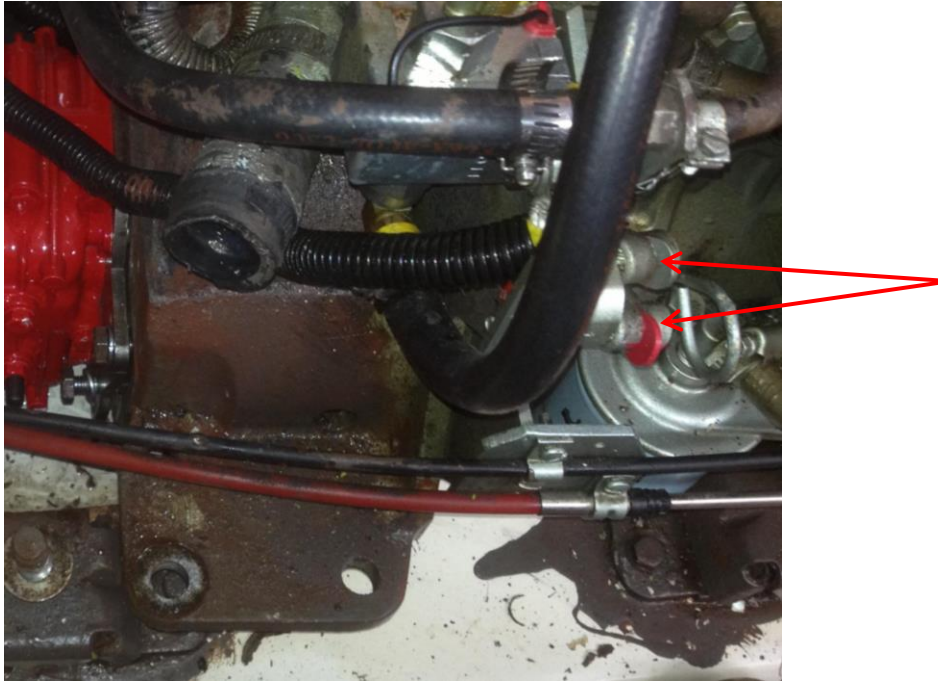
Removing the transmission does not require raising the engine if you have more than about 2 1/4" of shaft showing between the packing gland nut and the coupler. However the newer Hurst is about 0.8" longer than the older (non-obtainable) variety, so you will probably have to lift the engine to insert the new one. Which brings us to the damper plate removal.

They tell me it is theoretically possible to remove the damper plate without removing the bell housing. The arrow below indicates one of the five cap screws holding the damper plate to the engine flywheel. So I suppose you could remove the cap screw with a 3/16" Allen head and then progressively rotate the crankshaft to get the other cap screws and then maneuver the damper out the opening in the bell housing.



I could not do this with a standard Allen wrench because I couldn't get enough torque on the wrench (because of the Loctite). I could imagine that if you had a tool with a 3/16" Allen head, a 2 or 3 " extension and a 6 or 8" handle you could do this. Not having such a tool, I chose to remove the bell housing. This is a fair amount of work and does require lifting the engine 4 or 5 inches to get at the bolts at the bottom of the housing, not to mention that the rear engine mounts are part of the bell housing. It also required removing other things like linkage plates, fuel lift pumps, exhaust hose etc. , but none of this is too hard, just time consuming. If you don't have a good memory for where things go make

sketches or take pictures. Almost all the wires are just grounds that need to be bolted back to the engine chassis. Two exceptions are the lift pump connection, which is a spade that has 12 v for the lift pump and the small grommet that connects 12 v to the glow plug strip. One thing to be careful of is a circuit breaker that has two 12 v wires that could be hot (maybe not if the battery switch is off but I'm not sure). These wire connections are covered with red plastic boots but are painted over with grey paint and are indicated by the red arrows below.



I recommend peeling off the grey paint to expose the red plastic as a visual warning. Shorting these connection points to ground will make a very large spark in a very dangerous location. I taped them over with electrical tape before removing the mounting plate from the bell. In fact it might not be a bad idea to simply disconnect the battery leads at the batteries before fooling with the electrical connections

So here's what it looked like with the bell housing off:



And here is face on view:



Which gave me good access to the cap screws, which I removed with a standard Allen head and a crescent wrench for additional leverage.

Here is side by side of the new and old damper plate:



Call me crazy, but I went with John the Westerbeke mechanic's recommendation to replace with the identical R&D part. My reasoning went as follows:

The wear at the spline interface is caused by a "hammering" or "chatter" motion that they tell me occurs when the engine has no load (idling in neutral). You can see from the wear pattern on the spline collar that the wear is not symmetrical. It is all in the direction of the powered damper hitting on the spline in the counterclockwise direction as viewed from the flywheel end, which is the rotation direction of the Westerbeke crankshaft. This is consistent with the hammering of the spline collar on the tranny with the impulsive motion of the piston firing. With no load on the transmission spline, the spline shaft "bounces" on every impulse, which creates the hammering effect that wears the collar (and the shaft, to a lesser extent). If there is any load on the transmission (i.e. in gear) the shaft won't bounce but will stay in contact on the pressure side (the side that wears). So there won't really be any significant wear under that condition. That's the theory.

One obvious way to alleviate the problem is to always have some preload on the spline shaft, even when in neutral, to prevent the shaft from bouncing. I did notice that the new ZF 10 M Hurst was not nearly as "free-wheeling" as the older one. It required some torque to turn the shaft even in neutral. Is this because of "wear" in the older unit, or is it because of a design change in the newer one? They did something to it with the additional inch of length. If it has a shaft preload by design, then this might alleviate greatly, or maybe even eliminate, the hammering wear that occurs at idle. Time will tell.

There is an obvious resonance with the engine/engine mount combo that occurs at 800-900 rpm. The engine and compliant engine mount form a resonant torsional oscillator like a steel flywheel on a rubber shaft. The vibration that occurs happens because the piston firing impulses are at exactly the "natural" frequency of this torsional oscillator. I think it is reasonable to assume that the torsional hammering at the spline shaft is worse when the entire engine is undergoing this torsional vibration. This torsional resonance could be eliminated by some sort of "tuned" mount, like the shocks in some cars that allow sport vs. cruise mode stiffness settings, but I guess we shouldn't hold our breath waiting for this to happen.

It is easy to say "never idle the engine" but I don't think this is a practical solution. Yes, avoid long periods of unnecessary idling, but coming into a slip or mooring as well as when tying up or letting loose the lines it is usually necessary to idle for a time. Therefore I think one should idle at a speed that avoids the natural resonance, say at 1000 rpm or so. On the other hand, the function of the damper is to remove potentially harmful energy impulses that occur at gear shift time from reaching the engine itself. There is no "clutch" so these impulses can be significant. This says that you should always shift at the lowest possible rpm to keep the damper from having to dissipate too much impulse energy or even from "bottoming out" and transmitting the harmful impulse to the crankshaft.

The damper needs to be stiff enough so that under worse case conditions (say a prop strike on some unyielding object like a submerged railroad tie or a rock, or shifting at high engine rpm) the impulse energy is absorbed by the damper and not transmitted to the crankshaft due to "bottoming out" of the damping element (spring or plastic linkage). It has to be soft enough so that it absorbs enough energy from the normal gear shift impulses. It has to be "just right". Westerbeke claims that their design is "just right". They may or may not be correct, but all things considered, I think I will go with them. Hopefully with the new tranny there is a shaft preload that makes the spline wear issue moot. Another claimed advantage of the plastic damper design is that springs will eventually fatigue and break but the plastic has no wear out mechanism. This is somewhat contradicted by the observance of cracks in this damper by some. Maybe this was a defective unit?

I was advised that as long as I had the engine up I might as well change the engine mounts, so I did. The new design is slightly different. Here is the old and new mounts:



The new ones certainly look better but I'm not sure they were worth the price (\$185.10 ea). I noticed no difference in the 800-900 rpm resonance. I like to think that the old mounts were ready to fail in some way.

Conclusions:

I put in new ZF 10M Hurst transmission (\$1236), new R&D Damper (\$417.90) and four new engine mounts (\$185.10 ea). Counting taxes, freight, miscellaneous hoses and hardware It cost me about \$2700. I did all the labor myself and it took about 50 hours spread over about 2 weeks, which counts one false start.

One could argue that the entire problem could have been fixed with a Hurst rebuild (new spline shaft for maybe \$250) and a new spring type damper like the Sachs 1866 061 001 (\$180) for a total cost of less than \$500... (I still don't have results from the old Hurst post mortem.)

Did I do the right thing? I think so, for me, but it might not be the right choice for everyone.