TASK SHEET

Engine Alignment

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TOOLS:

- common hand tools
- combination wrenches
- large pry bar, 2x4, or hydraulic jack with spreader attachments
- feeler gauges, preferably go-no-go variety
- eye protection

PARTS:

- motor mounts if being replaced
- coupling fasteners if being replaced

MATERIALS:

- lightweight liquid lubricant
- vibration-detection lacquer such as Torque Seal

ABYC REFERENCE:

- P-6 Propeller Shafting Systems

For good engine-to-shaft alignment, the significant angled gap between this shaft coupling and the transmission flange must be eliminated by compensating for shaft sag and then shifting the engine on its mounts laterally and adjusting the mounts vertically.

INTRODUCTION:

This guide is designed to assist you in properly aligning engine and shaft couplings. Engine and propeller shaft alignment are critical aspects of propulsion system installation, reliability, and maintenance.

Incorrect alignment can result in a variety of undesirable outcomes, from excessive vibration and fuel consumption to transmission bearing and shaft failure. And it doesn't matter whether it's a well-used liveaboard cruiser or a new model fresh off the dealer's dock; any boat can suffer from misalignment. If a propeller and shaft require excessive effort to turn (you can check while the vessel is afloat or ashore), misalignment is a likely cause. Note that just because a vessel runs smoothly or the shaft is easy to turn doesn't mean the alignment is correct. Take no chances. For professionals, the *analysis* to determine if the alignment is out and if so, by how much is quick and easy, rarely taking more than a couple of hours.

It's important to distinguish between the two primary types of alignment that can be measured and adjusted in a boat's drivetrain. The first and most familiar is between the engine and shaft, often referred to as engine alignment. It assumes that the shaft is immovable (its position can be changed but not easily), and thus the engine must be moved to accommodate the shaft position. The second, shaft-to-bearing alignment, involves the relationship of the shaft to the bearing or bearings that support it, as well as the relationship between shaft and engine. It requires more specialized skills, tools, and experience, and will be the subject of a later task sheet.

Engine Alignment:

The primary area of concern for this process is the interface between the transmission output coupling and the shaft coupling, the faces of which must be centered relative to each other and perfectly parallel. Complicating the job is the phenomenon of shaft droop or sag. Because shafts and couplings are made of alloys whose primary content is iron, they are heavy. Consequently, depending upon the distance between the forwardmost bearing or support and the coupling, the sag can be substantial enough to confound alignment.

Before beginning an alignment analysis, shaft sag must be considered. The most accurate means of doing this is with optical- or laser-alignment gear, and what the American Bureau of Shipping refers to as "sighting through"—establishing a centered straight line through the bearings that support the shaft, up to the transmission output coupling. Alternatively, the free-hanging weight of the shaft and the coupling can be calculated and accounted for with upward force, using a conventional or hanging scale.

If you fail to account for shaft sag, it is possible to get the couplings to align, but the shaft will be bowed indefinitely, at rest and under way. Such a bow may lead to premature Cutless bearing wear and, in extreme cases, shaft failure. It is important that even where a prealignment is carried out ashore, a final engine alignment must be done with the vessel afloat, and in the case of a fiberglass or wood vessel, after it has been floating for at least 12 hours.

NOTE: This guide is not a substitute for following all applicable manufacturer and ABYC guidelines, as well as recognized marine industry best practices.


1

PROCEDURE:

1. Begin by carefully inspecting the components associated with alignment—motor mounts, mount shelves or engine beds, mount fasteners, the couplings, and the coupling fasteners. If mounts are heavily rusted, or the rubber material is cracked, separating from its metallic base, collapsed, oil soaked, or otherwise deteriorated, they should be replaced. The generally accepted life span for a flexible mount is 10 years. Performing an alignment with compromised mounts is a waste of time.

2. Remove the coupling bolts and separate the two couplings. If the bolts are rusty or otherwise damaged, they should be replaced. If the couplings are rusted, they should be cleaned and corrosion-inhibited or painted. If severely rusted, they may require replacement.


2

3. Alignment *cannot* be checked or adjusted while there's a flexible or a nonmetallic insert between the couplings. Remove inserts and mate the coupling faces directly. If the shaft cannot be brought forward far enough to accomplish this, you may need to temporarily install a precision shim to perform the alignment. One source for these is Spurs, spursmarine.com/spurs-shaft-spacer/.

4. Carefully inspect all flange-face surfaces including the pilot bushing and pilot receiver—a protrusion and indentation, respectively—near the center of the couplings. All should be free of dents, scoring, corrosion, or other damage, and they must engage with each other snugly. (You can't actually see them engage once assembled; however, the engagement can be felt.) If they are not a true fit due to corrosion, damage, or mismatch, the couplings may be off-center, making alignment impossible. If there's any doubt, and especially if the coupling shows evidence of having been hammered, take it to a propeller-shaft machine shop for analysis and repair. If the transmission coupling is damaged in any way, it too should be analyzed and repaired or replaced.

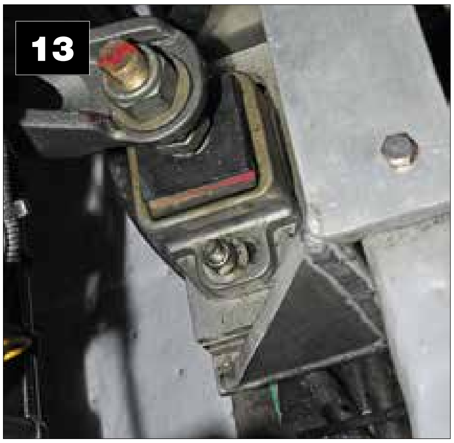
4

5. Spray or rub onto the coupling faces and pilot bushing a light lubricant such as CRC's 6-56, WD-40. This will aid in engagement and in rotating them during alignment.

6. Pre-position the transmission output coupling using either the optical- or laser-alignment position of the shaft centerline. This will ensure that this coupling is centered with what will be the shaft centerline, but it does not guarantee alignment; the coupling faces must be centered *and* parallel.


6

7. If you can't use a laser or optical sight because the shaft cannot be removed, you must apply upward force to the shaft equal to its overhanging weight *and* the weight of the coupling. Shaft weight per foot can be found online from shaft manufacturers: wbmetals.com/wp-content/uploads/2021/01/WBM_Shafting_Data_Brochure.pdf. Shaft overhang is measured from the forwardmost support, usually a rigidly mounted stuffing box, or Cutless bearing at the forward end of the shaftlog. Some interpretation is needed here, because even flexibly mounted stuffing boxes provide some support.



8. Once the shaft sag has been accounted for, press the coupling faces together tightly, and rotate the shaft coupling against the transmission coupling by hand a few times to ensure a good fit.

9. Insert the thickest feeler gauge that will fit into the gap between the two coupling faces at any point. A maximum of approximately 0.001″ (0.025mm) of misalignment is considered acceptable for every inch of coupling face diameter, with an overall maximum of no more than 0.004″/0.1mm (some transmission manufacturers, notably Borg Warner, manufacturer of the Velvet Drive, call for a maximum misalignment of 0.003″/0.08mm overall). Less is always better when it comes to alignment clearance.

10. At this point, rotate the shaft coupling 180°. The gap and its location should remain constant. Then do the same for the transmission output coupling; again, the gap size and location should remain constant. (See step 12 for details.)

11. If the gap is larger, the motor mounts will have to be adjusted and/or shimmed to diminish the gap. The motor mounts will act as a pivot point, so lowering the front of the engine will cause the output coupling, at the rear of the engine, to be raised. Lowering the rear mounts will cause the output coupling to drop. The geometry takes a little getting used to. If, for instance, you were to view the couplings from aft facing forward and a gap existed at the 3 o'clock position, then the front of the engine would have to be moved to starboard. If a gap existed at the 6 o'clock position, the front of the engine would have to be lowered. To close a gap at the 4 o'clock position, you would lower the left front mount. To close the gap at the 10 o'clock position you would raise the right front mount, and so on. If you find insufficient adjustment in the mounts to correct the alignment, mount shelf or engine bed/stringer modification may be necessary—more on that below.

12. Adjust mounts so all are in roughly equal compression. It is possible to inadvertently adjust them so that, if looking down on the engine, the mounts in the 10 and 4 o'clock positions are in compression, and the mounts in the 2 and 8 o'clock positions are in tension. This can lead to a teetering effect and vibration. Some mount manufacturers include a feature to determine mount loading.

13. Lateral movement, required for centering and closing gaps at the 3 and 9 o'clock positions, is achieved by sliding mounts port and starboard. Most mounts accommodate this with slots or ovals in their bases. Moving the engine from side to side can be challenging. For larger engines you may need a hydraulic jack, while a simple pry bar may suffice for smaller engines. Secure mounts to brackets or stringers with a minimum of grade 5 fasteners, denoted by three radial dashes 120° apart on their heads. For fasteners in slotted or oval mounting holes use extra-thick, distortion-resistant washers.

14. When the coupling face gap size is acceptable, rotate the couplings 180° and recheck the measurements. Turning the coupling any amount should not change the size or relative location of the gap. If there's any change, the coupling, shaft, or fit between the two is not true. Remove the shaft and shaft coupling and take them to a shaft shop for "fitting and facing," a process wherein the coupling, while fit to the shaft, is machined on a lathe to ensure that its face is perpendicular to the shaft's centerline.

15. After adjustment is complete, and the gap is minimized, install the coupling bolts. They should be sequentially and cross-torqued all the way up to their maximum torque rating.

16. Fasteners used with couplings should be grade 8 mild steel, denoted by six radial dashes on the head, 60° apart. Lock washers or locking nuts are essential, and a minimum of two threads of the bolt should protrude past the nut to ensure full load-bearing ability and proper engagement with the locking insert in locking nuts. *Never use stainless steel bolts*.

17. Once fasteners are installed and torqued, they, and steel couplings, should be painted or otherwise corrosion-inhibited, as mild steel is prone to rapid rusting. Do *not* apply thread antiseize compounds to alignment-related threads, including motor-mount studs and coupling fasteners.

18. When the alignment is complete, the motor-mount adjustable screws should be close to the middle of their travel. If they are fully depressed or fully extended, there is no room for future fine-tuning, and in the latter case the increased leverage raises the likelihood of failure. In some cases, mounts may require shims (acceptable shim materials includes aluminum, steel and fiberglass sheet—GPO3, G10 or comparable—but never UHMW polymer) to offset overextension of the studs. In other cases, brackets or stringers may require modification to lower an adjustable mount to improve exposed stud length or to complete alignment.

19. As an optional final measure of proper engine alignment, you can employ a dial indicator to quantify any shaft irregularity or "runout." Setting up a dial indicator at the shaft where it enters the coupling, and then slowly rotating the shaft by hand, will confirm whether the shaft is centered on the transmission coupling centerline.

20. Once complete, sea-trial the vessel. Then check the torque of all fasteners related to alignment and ensure that all are adequately corrosion-inhibited. Consider applying a vibration-detection lacquer such as Torque Seal, to alert users and service personnel to fasteners that have loosened.

About the Author: *For many years a full-service yard manager, Steve now works with boat builders and owners and others in the industry as Steve D'Antonio Marine Consulting. He is an ABYC-certified Master Technician and sits on that organization's Engine and Power-train, Electrical, and Hull Piping Project Technical Committees. He is also technical editor of* Professional BoatBuilder.