

# Gear Mesh Assembly

Email your question — along with your name, job title and company name (if you wish to remain anonymous, no problem) to: [jmcguinn@geartechnology.com](mailto:jmcguinn@geartechnology.com), or submit your question by visiting [geartechnology.com](http://geartechnology.com).

## QUESTION

**When assembling a pair of gears, what is a good method for setting and checking their mesh?**

### Expert response provided by: Robert Wasilewski, Arrow Gear Company.

Proper setting of gears usually involves checking backlash and tooth contact pattern. Backlash can be checked using a dial test indicator applied to a tooth on one member of the mesh and moving that member back and forth while holding the other member still. Contact pattern checks require painting some or all of the teeth of at least one member with gear marking compound and rotating the gears to see how they contact in the marking compound.

That's the simple answer.

What do you do if you do not like the results you get? This really depends on the type of gears that you are assembling. Parallel axis gearing, spurs and helicals usually offer very little opportunity for change. Most of the time, the two supporting shafts are fixed in their relationship to each other by the location of the gearbox support bearings; all you can do is move the shafts axially in relation to each other. If the gears have crowning, the axial movement can be used to center the contact pattern. The backlash is controlled by tooth thickness and center distance. Since neither can be changed, you cannot adjust backlash; all you can do is measure the backlash in several positions to make sure whatever variation present is acceptable.

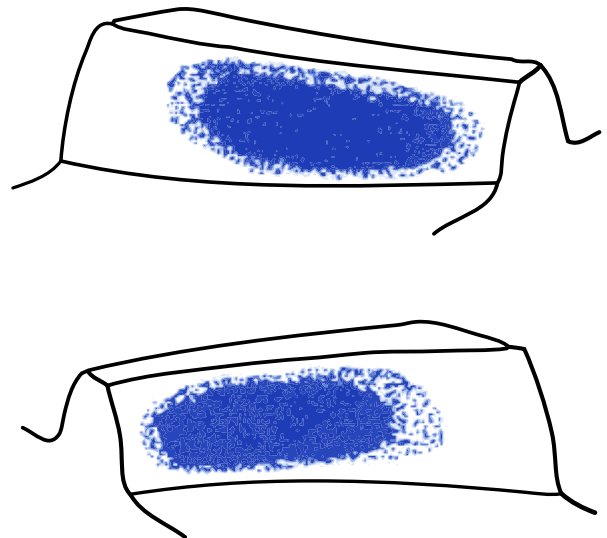
Non-parallel axis gearing is another story. While the shafts are still fixed in their relationship to each other, axial movement can greatly affect the contact pattern and the backlash. This is true for worm, hypoid and bevel gears. How do you get proper contact and backlash? By mounting the gears at the position the manufacturer made them at. Traditionally, bevel and hypoid gears have their mounting dimensions marked on each part. When this is the case you should use those dimensions by measuring the gearbox components that affect the position of the gears and calculate the thickness of any shims used to adjust their position; the shims are generally under bearing retainers or housing flanges. If shims are not in the design, components may have to be machined to adjust the gears position. The most common component to be machined would typically be a steel spacer. It is very important to note that you need to measure the individual components you are using, and do not just use the nominal dimensions from the component drawings. A little bit of adding and subtracting will show that the stack-up of tolerances from all the components can easily place the gears in the wrong position. If you measured correctly and calculated the shim or spacer width correctly, you should get the same contact

pattern and backlash the manufacturer put in to the gear set. If you are rebuilding a gearbox, do not just put back the old shims or spacers without verifying they are the right thickness.

What you cannot do is just put bevel gears together and only check the backlash. This is one of the most common mistakes made at assembly. Bevel gears can be assembled at any number of positions and still have the correct backlash, but only being at or very near the marked mounting distance will yield the correct contact pattern and backlash. By the way, you can have the correct contact pattern and not have the proper backlash too! How can that be? As you increase the ratio in bevel gears, each member begins to have a different amount of effect on the contact pattern and backlash. The pinion becomes the dominant member that controls the contact pattern, while the gear, or wheel, principally controls backlash. So as you get to higher ratios it is more important to position the pinion as close as possible to the marked mounting dimension. The wheel can be brought in to mesh to adjust backlash. Both members control backlash and contact pattern equally when the gear set is at a ratio of 1-to-1. At 1-to-1 ratio, each member must be adjusted.

If the gears are not marked with mounting distances — or it is just too difficult to measure — you have to resort to a trial-and-error method of looking at contact patterns and adjusting the components until you have an acceptable pattern and

Desirable Bearing Pattern



backlash. There are several issues with this method. If the gearbox is not designed with shims but uses ground spacers, it can become an expensive and tedious process. Also, you have to judge if the contact pattern is in fact correct. Contact patterns seldom have the nice picturesque appearance that you see in the literature. The shape and size of the pattern can vary widely from the classic elliptical pattern. If possible, request copies of the contact pattern from the manufacturer of the gears when you order them. These can be transfers of actual marking compound lifted from the tooth surface with transparent tape or photos. Transfers are best. The manufacturer may also be able to leave the pattern and compound on the gears when they ship them to you so you see exactly what it looks like on the teeth. (Make sure you record that because it will change if the gears are assembled and run again at the wrong position). You have to order all of those options; they are not customary.

The position is usually the overriding factor to look at. It is very easy to overlook a positioning error because you do not know how to interpret the appearance of the contact pattern. You need to look at contact patterns on both sides of the teeth—even if the gears only turn in one direction. Assembly people often give up before they get the proper setup.

There is a bit of a technique involved in applying tooth marking compound. Also, if you do not know what the contact pattern is supposed to look like, you need some guidance as to how to move the gears and what to look for. That is beyond the scope of a brief article like this one, but is very well documented in a national standard. ANSI/AGMA 2008-D11 — Assembling Bevel Gears — is available from the American Gear Manufacturers Association — [www.agma.org](http://www.agma.org). The document has examples of contact patterns, and what to do to correct them, as well as a detailed procedure on how to apply and use tooth marking compound. There are also detailed examples of measuring components to calculate shims, as well as tooling examples that can help reduce calculations and assembly time. The document is not only intended for the assembly room, but also gives the gearbox designer a great idea of what to provide to make assembly quicker, better and more accurate.



**Robert Wasilewski** is engineering services manager for Arrow Gear Company, and Chairman of the AGMA Bevel Gearing Committee.

