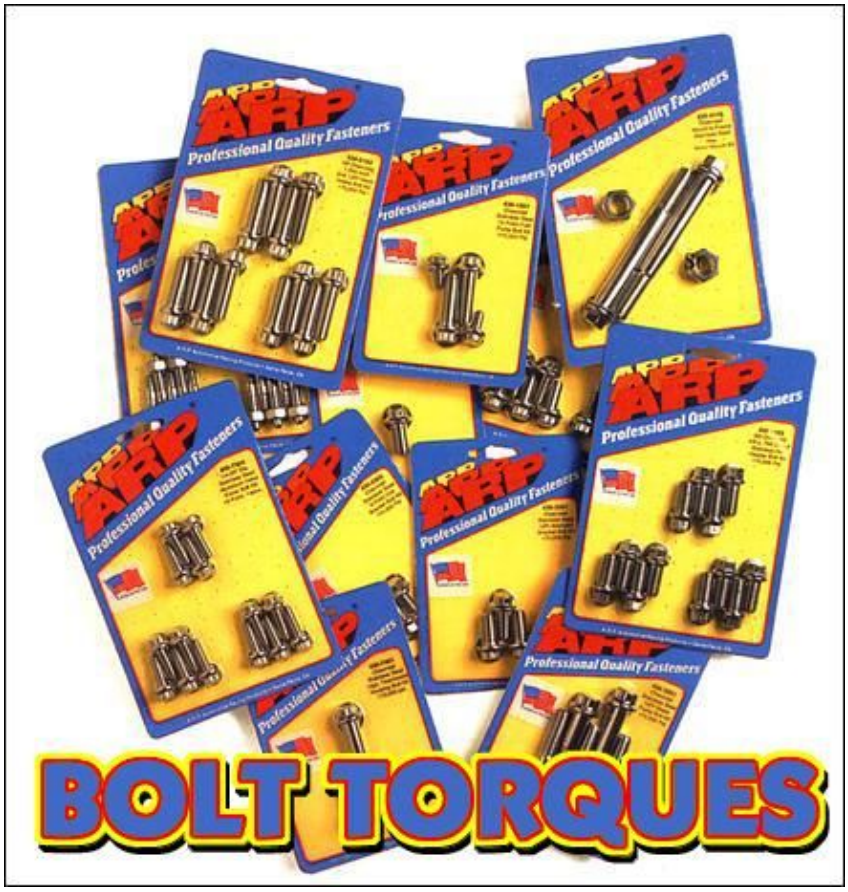


Bolt Torques

Gaining the right tension on highly stressed bolts is critical to their longevity.

Courtesy of ARP

There are three methods that can be employed to determine how much tension is exerted on a fastener:

1. Using a torque wrench
2. Turning the fastener a predetermined amount (torque angle)
3. Measuring the amount of stretch

Of these methods, use of a stretch gauge is the most accurate.

It is important to note that in order for a fastener to function properly it must be "stretched" a specific amount. The material's ability to "rebound" like a spring is what provides the clamping force. You should know that different materials react differently to these conditions - and companies design fasteners to operate within specific ranges. If a fastener is over-torqued and becomes stretched too much, you have exceeded the yield strength **and the fastener is therefore ruined.** If after torqueing the fastener is longer than manufactured - even if only by 0.001 inches - it is in a partially failed condition.

Therefore, companies engineer their fasteners with the ductility to stretch a given amount and then rebound for proper clamping. Heat, primarily in aluminum, is another problem area. Because the thermal expansion rate of aluminum is far greater than that of steel, it is possible to stretch a fastener beyond yield as the aluminum expands under heat. An effective way of counteracting material expansion is through producing a more flexible bolt.

The Torque Angle Method

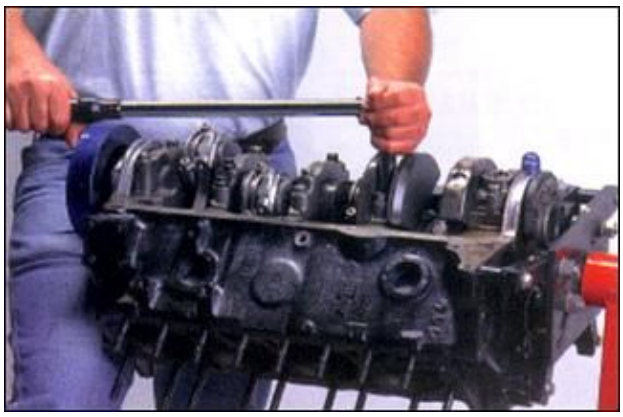
Since the amount that a bolt or nut advances per degree of rota-tion is determined by the thread pitch, it would appear that the amount of stretch in a given bolt or stud can be accurately predicted by measuring the degrees of turn from the point where the underside of the bolt head or nut face contacts the work surface. Termed the "torque angle" method, this procedure has long been the standard of civil engineering. It has been suggested that torque angle is a relatively simple and valid procedure to use in automotive "blind" installations - where it is not possible to physically measure the actual bolt stretch.

ARP has conducted extensive evaluations of the torque angle method. The company has concluded that, for our purposes, it is suitable only when individually calibrated for each installation. Simple calculation of bolt stretch based on thread pitch is not accu-rate. No material is incompressible. When a bolt or a stud is pre-loaded or stretched, the components being clamped compress to some small extent. When we are looking for bolt stretch of only a few thousandths of an inch, the amount of clamped material compression becomes a very real factor.

Our investigation has shown that installed stretch is dependent, not only on the pitch of the thread and the degree of rotation, but also on the amount of compression of the clamped components, the length of the male fastener, the amount of engaged thread, the type of lubrication and the number of times that the fastener has been cycled. For example, for the same degree of rota-tion, the actual amount of bolt stretch will be critically different between an aluminum cylinder head and a cast iron cylinder head - or a steel main cap on an aluminum block and a steel main cap on a cast iron block. Further, there is a significant difference between the long and short cylinder head bolts or studs on the same head.

The torque angle method can be accurate - but only if each individual installation has been previously calibrated by direct measurement of bolt stretch. When using the torque angle method, it is best to begin rotation from some small measured torque - no more than 10 ft-lb - rather than the first point of contact with the work face. To achieve accuracy it is also best to cycle the fasteners five times before either calibrating or installing.

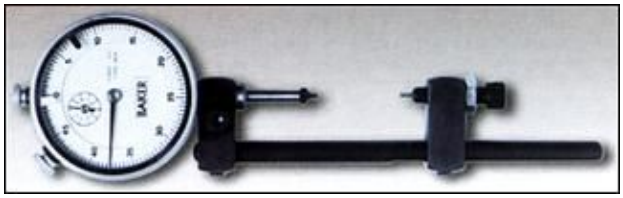
Using a Torque Wrench



If the stretch method cannot be used in a particular installation, so that the fasteners must be installed by torque alone, there are certain factors that should be taken into account.

1. The friction factor changes from one application to the next. That is, the friction is at its highest value when the fastener is first tightened. Each additional time the fastener is torqued and loosened, this value gets smaller. Eventually the friction levels out and becomes constant for all following repetitions. Therefore, new fasteners should be tightened and loosened through several cycles before applying final torque. The number of times depends on the lubricant. For all situations where ARP lubricants are used, five cycles are required before final torqueing.

The Stretch Gauge



We highly recommend using a stretch gauge when installing rod bolts and other fasteners where it is possible to measure the length of the fastener. It is the most accurate way to determine the correct pre-load in the rod bolt.
Simply follow the manufacturer's instructions to determine the degree of stretch required. For example, ARP recommends a stretch of 0.0065 inches for their Nissan VG30ET rod bolts. When the bolt has stretched the specified amount, the correct pre-load, or torque, has been applied. If there is a permanent increase in length by 0.001 inches, or if there is bolt deformation, the bolt should be replaced.

http://www.arp-bolts.com