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Glossary of Fastener and Bolted Joint Terms

- ANGULARITY** The underfaces of the nut and the bolt head should be exactly perpendicular to the thread or shank axes. If the angle between the face and the axis is, for example, 86" or 94", the fastener is said to have an angularity of 4" (sometimes called PERPENDICULARITY).
- ANODE** That electrode in a battery or corrosion cell which produces electricity. It is the electrode, which is destroyed (corrodes).
- AREA, STRESS OR TENSILE STRESS** See STRESS AREA. **BODY** See BOLT, PARTS OF.
- BOLT** Officially, a threaded fastener designed to be used with a nut. The word is often used interchangeably with THREADED FASTENER for convenience.
- BOLT CIRCLE DIAMETER "BCD"** The dimension on a circular flange from the center of one bolt hole to the center of the bolt hole directly across the flange. Sometimes referred to as PCD or Pitch Circle Diameter.
- BOLT LOAD** See CLAMPING FORCE.
- BOLT, PARTS OF** See Fig. A.1.

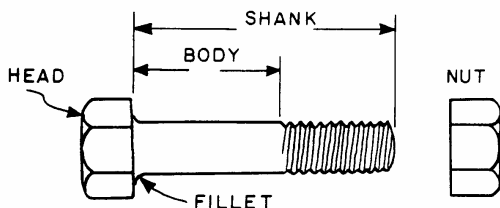


FIGURE A.1 Parts of a bolt.

- BRITTLE** A bolt is said to be brittle if it will break when stretched only a small amount past its yield point. (Compare DUCTILE.) Being notch sensitive and non elastic. These materials however are generally very, very strong and have a very high yield point.
- CATHODE** That electrode in a battery or corrosion cell which attracts electrons.
- CLAMPING FORCE** The force, which a threaded fastener exerts on the joint members, it is holding or clamping together. This force is basically parallel to the axis of the bolt, and is initially equal to the PRELOAD in the bolt.
- CODE** The Boiler and Pressure Vessel Code published by the American Society of Mechanical Engineers (ASME). For the Europeans there is an equivalent European code, generally based on DIN standards. Many vessels and their bolting are also designed to this code. There are various other codes such as BSI (British Standards Institute), the Japanese standards, Russian ones and so on.



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COEFFICIENT OF FRICTION The ratio of the force that maintains contact between an object and a surface and the frictional force that resists the motion of the object.

CORROSION CELL A natural "battery" formed when two metals having different electrical potentials (an ANODE and a CATHODE) are connected together in the presence of a liquid (the ELECTROLYTE).

CREEP A slow flow of metal when under high temperature or great pressure

DIMENSIONS OF BOLT See Fig. A.2.

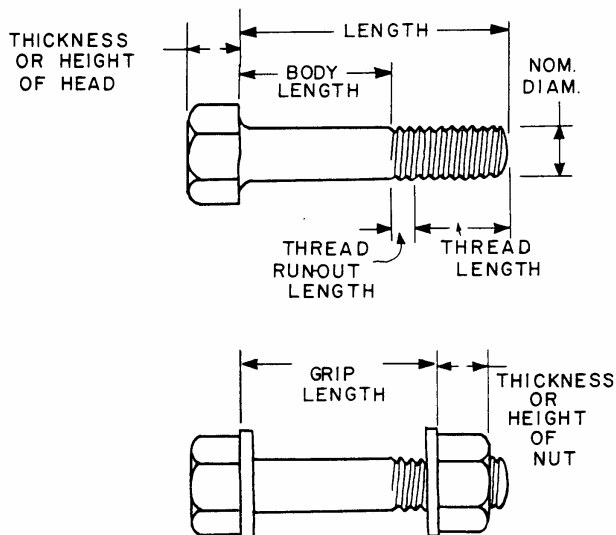


FIGURE A.2 Bolt dimensions.

DUCTILE If a bolt can be stretched well past its yield point before breaking it is said to be DUCTILE. (See also BRITTLE.) Note: rather than ductility and brittleness it is perhaps more correct to refer to the elastic properties of a bolt material. Every material has two key points; the yield strength and the ultimate tensile strength. The range between these two points is called the plastic region. A very elastic material has a long plastic region. That is to say it would take further load or force to get it to the rupture point well after the yield point is reached. A material which is "Notch Sensitive", that is to say almost non elastic, that is to say with a very short if any "plastic region" is liable to rupture without warning soon after passing the yield point. Hard non-elastic materials, such as Marejan steel for example, are also prone to fatigue failure, even when tightened within the elastic limit.

ECCENTRIC LOAD The EXTERNAL LOAD on a fastener or groups of fasteners is said to be eccentric if the resultant of that load does not pass through the center of the group of fasteners (ECCENTRIC SHEAR LOAD) or does not coincide with the bolt axis (ECCENTRIC TENSILE LOAD).



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| ELASTIC | Returning to or capable of returning to an initial form or state after deformation |
| ELONGATION | Increase in length per unit length of effective bolt length. This term is however used more widely as a reference to the stretch in a given bolt when tightening |
| EFFECTIVE LENGTH OF A BOLT | The GRIP LENGTH plus some portion of the bolt (often one-half of the thickness of the nuts) which lies within the nut(s) plus some portion (often one-half the thickness) of the head. Used in stiffness and stretch calculations. |
| EFFECTIVE RADIUS OF NUT, OR BOLT HEAD, OR THREADS | Distance between the geometric center of the part and the circle of points through which the resultant contact forces between mating parts passes. Must be determined by integration. |
| ELECTRODE | The two metallic bodies in a battery or CORROSION CELL which give up electrons (the ANODE) or which attract them (the CATHODE). |
| ELECTROLYTE | The liquid with which the ELECTRODES of a battery or CORROSION CELL are wetted. |
| EMBEDMENT | Localized plastic deformation in heavily loaded fasteners allows one part to sink into, or smooth the surface of, a softer or more heavily loaded second part. Nuts embed themselves in joint surfaces. Bolt threads embed themselves in nut threads, etc. |
| ENDURANCE LIMIT | That stress level below which a bolt or joint member will have an essentially infinite life under cyclic fatigue loads. This will depend on: The initial level of stress put in the bolt and the elastic properties of the bolt material itself. |
| EXTENSOMETER | Any instrument which measures the change in length of a part as the part is loaded. |
| EXTERNAL LOAD | Forces exerted on fastener and/or joint members by such external factors as weight, wind, inertia, vibration, temperature expansion, pressure, etc. Does not equal the WORKING LOAD in the fastener. The working load in the fastener is described as that load required to compress and seat the gasket + any external force which might act on the bolt. This last bit is generally referred to in ASME as the Hydrostatic end force |
| FASTENER DIMENSIONS | See DIMENSIONS OF BOLT. |
| FILLET | Transition region between bolt head and shank, or between other changes in diameter. See BOLT, PARTS OF |
| FLANGE ROTATION | Angular distortion of a flange under the influence of bolt and reaction forces. Measured with respect to the center of the cross section of the flange. See Fig. A.3. |



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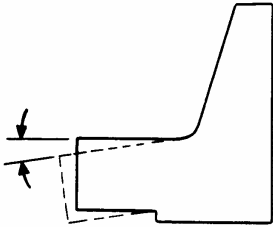


FIGURE A.3 Flange rotation.

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| GALLING | An extreme form of adhesive wear, in which large chunks of one part stick to the mating part (during sliding contact). |
| GASKET STRESS | The compressive load/unit area required to fully compress the gasket |
| GRIP LENGTH | Combined thickness of all the things clamped together by the bolt and nut, including washers, gaskets and joint members. (See DIMENSIONS OF BOLT.) |
| HEAD OF BOLT | See BOLT, PARTS OF. |
| HEIGHT OF HEAD OR NUT | See THICKNESS OF HEAD OR NUT under DIMENSIONS OF BOLT. |
| HISTOGRAM | A bar chart, used by statisticians to illustrate the distribution of sample data. |
| IMPACT WRENCH | An air or electric powered wrench in which multiple blows from tiny hammers are used to produce output torque to tighten fasteners. |
| INCLUSIONS | Small pieces of nonmetallic impurities trapped within the base metal of, for example, a bolt. |
| JOINT DIAGRAMS | Mathematical diagrams which illustrate the forces on and deflections of fasteners and joint members. |
| K-FACTOR | An experimental constant used to evaluate or describe the ratio between the torque applied to a fastener and the PRELOAD achieved as a result |
| LENGTH, EFFECTIVE | See EFFECTIVE LENGTH. |
| LENGTH OF BOLT | See DIMENSIONS OF BOLT |
| LINEAR REGRESSION ANALYSIS | A mathematical process, usually performed on a computer or calculator, to pick that straight line which best fits a group of data points. |



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| LOAD LOSS TRANSFER: | The amount of overload necessary to be applied by the tensioner to the bolt in order to compensate for the load loss that occurs when the load is transferred from the tensioner puller threads onto the actual bolt/nut threads. The amount of extra load required will depend on many factors such as the stiffness of the joint, the gasket being used and its compression stress, the effective length of the bolt, the number of tensioners being used, the tensioning procedure being applied, the bolt material, the "squareness" of the bolt to the flange surface, the number of interfaces (washers for example), etc... In truth many of these things also apply to torquing methods and with far less predictable effects. With tensioning however all these cumulative effects can be catered for. As a rule of thumb example: using 50% tensioning on a standard ANSI flange will require some 20-25% over load on the first pass and some 15-20% overload on the second pass. As most ANSI flange bolts are tightened to between 30 and 50% of the bolt strength this leaves plenty in hand to apply the required overload. |
| LOCK NUT | A nut that provides extra resistance to vibration loosening, either by providing some form of PREVAILING TORQUE, or in free-spinning lock nuts, by deforming, cramping, and/or biting into mating parts when fully tightened. |
| MEAN VALUE | The average value of a number of data points. Computed by dividing the sum of all data by the number of data points. |
| NOMINAL DIAMETER | The "catalog diameter" of a fastener. Usually roughly equal to the diameter of the body, or the outer diameter of the threads. |
| NONLINEAR BEHAVIOR | A fastener or joint system is said to exhibit nonlinear behavior when the relationship between the EXTERNAL LOAD on the joint and deformation of the parts is nonlinear, or when the relationship between increasing PRELOAD and deformation is nonlinear. |
| NOTCH SENSITIVE | See Brittle |
| NUT FACTOR | See K-FACTOR. |
| PERPENDICULARITY | See ANGULARITY. |
| PITCH | The nominal distance between two adjacent thread roots or crests. (See THREAD NOMENCLATURE.) |
| PRELOAD | The tension created in a threaded fastener when the nut is first tightened. Often used interchangeably, but incorrectly, with WORKING LOAD or bolt force or bolt tension. (See also CLAMPING FORCE.) |
| PREVAILING TORQUE | Torque required to run a nut down against the joint when some obstruction, such as a plastic insert in the threads, or a noncircular thread, or other, has been introduced to help the fastener resist vibration loosening. Prevailing torque, unlike "normal" torque on a nut or bolt, is not proportional to the PRELOAD in the fastener. |
| PROOF LOAD | The maximum, safe, static, tensile load which can be placed on a fastener without yielding it. Sometimes given as a force (lb or N) sometimes as a stress (psi or KPa). |



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| PRYING | The magnification of an EXTERNAL LOAD by lever action when that load is an ECCENTRIC TENSILE LOAD. |
| RADIUS, EFFECTIVE | See EFFECTIVE RADIUS. |
| REGRESSION LINE | See LINEAR REGRESSION ANALYSIS. |
| RELAXATION | The loss of tension, and therefore CLAMPING FORCE, in a bolt and joint as a result of EMBEDMENT, vibration loosening, gasket creep, differential temperature expansion, etc. |
| RESIDUAL PRELOAD | A term that is sometimes used incorrectly. If they mean permanent elongation in the bolt, this would have been caused by external forces and not by a natural phenomenon!! If a bolt is tightened to within it's elastic limit, below it's yield point, it will always return to its original length. If it is taken into the plastic region, it will then demonstrate a "permanent elongation" after loosening. Depending on the material this is not necessarily harmful. Another external phenomenon which produces permanent elongation in bolts is "creep". This is the result of combined stress and temperature. It is often a problem for example on turbine and high tempo valve bolting. High stress concentration on the first two threads of engagement, combined with elevated temperature makes the material "creep" and produces permanent elongation. |
| ROLLED THREAD | A thread formed by plastically deforming the surface of the blank rather than by cutting operations. Increases fatigue life and thread strength, but is not possible (or perhaps economical) on the larger sizes. |
| ROOT AREA | Described as the cross sectional area of a threaded fastener on it's smallest cross section or diameter, which is to say at the root of the threads. |
| EFFECTIVE AREA (As) | This is the area of the bolt used in calculations and is described as the area of a cross section of the bolt cut at perpendicular angle to that of the axis of the bolt. |
| ROOT STRESS | The stress seen by the bolt for a given load on it's smallest cross sectional (Root) area |
| ROTATION OF FLANGE | See FLANGE ROTATION. |
| SCATTER | Data points or calculations are said to be scattered when they are not all the same. |
| SCATTER DIAGRAM | A chart on which individual data points are all plotted, illustrating their SCATTER. |
| SCREW | Threaded fastener designed to be used in a tapped or untapped hole. |
| SHANK | That portion of a bolt which lies under the head. (See BOLTS, PARTS OF) |
| SEIZE | To cohere to a relatively moving part through excessive pressure, temperature, or friction used especially of machine parts (as bearings, brakes, or pistons) b : to fail to operate due to the seizing of a part -- used of an engine. |
| SLUG WRENCH | A box wrench with an anvil on the end of the handle. Striking the anvil with a sledgehammer produces torque. Called a flogging wrench in the U.K. |



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- SPHERICAL WASHER** A washer whose upper surface is semispherical. Used with a nut whose contact face is also semispherical. Reduces bending stress in a bolt or stud, by allowing some self-alignment and/or some compensation for non-parallel joint surfaces or **ANGULARITY**.
- SPRING CONSTANT** The ratio between the force exerted on a spring (or a bolt) and the deflection thereof. Has the dimensions of force per unit change in length (e.g., lb/in. Also called **STIFFNESS**)
- STANDARD DEVIATION** A statistical term used to quantify the **SCATTER** in a set of data points. If the standard deviation is small, most of the data points are "nearly equal. A large deviation means less agreement.
- STIFFNESS** See **SPRING CONSTANT**
- STRENGTH OF BOLT** An ambiguous term, which can mean **ULTIMATE STRENGTH** or **PROOF LOAD** or **ENDURANCE LIMIT** or **YIELD STRENGTH**.
- STRESS AREA** The effective cross-sectional area of the threaded section of a fastener. Used to compute average stress levels in that section. Based on the mean of pitch and minor diameters (See **THREAD NOMENCLATURE & EFFECTIVE AREA**.)
- STUD** A headless threaded fastener, threaded on both ends, with an unthreaded body in the middle section, or threaded from end to end. Used with two nuts, or with one nut and a tapped hole.
- TENSILE STRENGTH** See **ULTIMATE STRENGTH**.
- TENSILE STRESS AREA** See **STRESS AREA**.
- TENSIONER** A hydraulic tool used to tighten a fastener by stretching it rather than by applying a torque to the nut. After the tensioner has stretched the bolt or stud, the nut is run down against the joint with a modest torque,(in the majority of cases by hand) and the tensioner is disengaged from the fastener. The nut holds the stretch produced by the tensioner.
- TENSIONER APPLIED LOAD:** This is the calculated hydraulic oil pressure multiplied by the tensioner hydraulic area to impart the required preload in the fastener + that amount required for load loss transfer.
- TENSIONER RESIDUAL LOAD:** Is the preload left in the bolt after it has been tensioned and the tensioner has been de-pressurized.



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THICKNESS OF NUT OR OF BOLT HEAD See DIMENSIONS OF BOLT (also called HEIGHT).

THREAD LENGTH Length of that portion of the fastener which contains threads cut or rolled to full depth. (See DIMENSIONS OF BOLT.)

THREAD NOMENCLATURE See Fig. A.4.

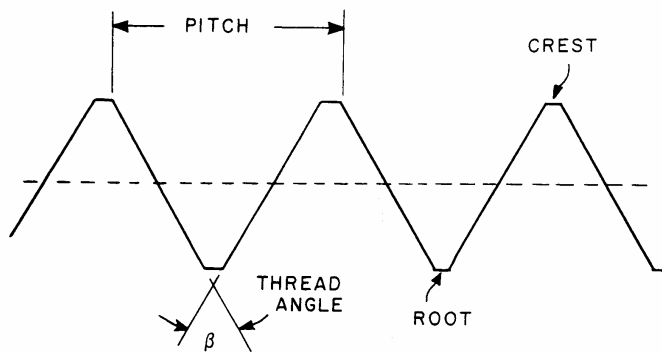


FIGURE A.4 Thread nomenclature.

THREAD RUN-OUT That portion of the threads which are not cut or rolled full depth, but which provide the transition between full-depth threads and the body or head. (See BOLT, PARTS OF.) Officially called thread washout or vanish, although the term run-out is more popular. (Run-out is officially reserved for rotational eccentricity, as defined by Total Indicator Readings or the like.)

THREADED FASTENER Studs, bolts, and screws of all sorts, with associated nuts. One of the most interesting, complex, useful--and frustrating components yet devised.

TORQUE The twisting moment, product of force and wrench length, applied to a nut or bolt (for example).

TORQUE MULTIPLIER A gearbox used to multiply the torque produced by a small hand wrench (usually a TORQUE WRENCH). The output of the multiplier drives the nut or bolt with a torque that is higher, and a speed that is lower, than input torque and speed. There is no torque gauge or read-out on the multiplier.

TORQUE PACK A geared wrench that multiplies input torque and provides a read-out of output torque. In effect a combination of a TORQUE WRENCH and a TORQUE MULTIPLIER.

TORQUE WRENCH A manual or power wrench that incorporates a gauge or measuring apparatus of some sort to measure and display the amount of torque being delivered to the nut or bolt. All wrenches produce torque. Only a torque wrench tells how much torque.

TRANSDUCER A device which converts one form of energy into another. An ultrasonic transducer, for example, converts electrical energy into acoustic energy (at ultrasonic frequencies) and vice versa.



TURN-OF-NUT Sometimes used to describe the general rotation of the nut (or bolt head) as the fastener is tightened. More often used to define a particular tightening procedure in which a fastener is first tightened with a pre-selected low torque, and is then tightened further by giving the nut an additional, measured, turn such as "three flats" (180").

ULTIMATE STRENGTH The maximum tensile strength a bolt or material can support prior to rupture. Always found in the plastic region of the stress-strain or force-elongation curve, and so is not a design strength. Also called **TENSILE STRENGTH** and ultimate tensile strength. Just for information: many fasteners in the automotive industry are in fact taken to the plastic region, by design. Materials with very long plastic regions are of course selected for this purpose.

ULTRASONIC EXTENSOMETER An electronic instrument that measures the change in the length of a fastener ultrasonically as, or before and after, the fastener is tightened. (See also **EXTENSOMETER**). The UT instrument measures time of sound wave travel from the top to the bottom of the fastener. Comparing the reading when loose (reference) to that once tightened gives a time difference which is directly proportional to the physical elongation in the fastener: **WARNING:** the relationship of time of flight to elongations is greatly effected by many external factors such as stress levels, stress patterns, transducer characteristics, temperature, and many others. This method of measuring is about the most accurate that exists, even better than strain gauges, **BUT IT MUST BE CORRECTLY CALIBRATED FOR EACH AND EVERY APPLICATION!!!!** There is no such thing as an empirical calculated sound velocity, stress factor, temperature compensation, etc... as many makers claim or as indeed many service providers assume!!

WIDTH ACROSS FLATS A principal dimension of nuts, or of bolt heads. (See Fig. A.5.)

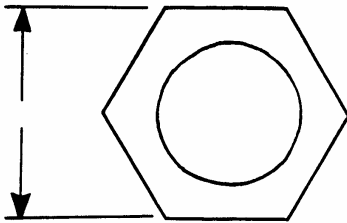


FIGURE A.5 Width across flats.

WORK HARDENING The slight increase in hardness and strength produced when a body is loaded past its yield point. Also called strain hardening.

WORKING LOAD The tension in a bolt in use; tension produced by a combination of **RESIDUAL PRELOAD** and a portion (usually) of any **EXTERNAL LOAD**. The **JOINT DIAGRAM** is usually used to predict the approximate working load a fastener will see in service.

YIELD STRENGTH That stress level which will create a permanent de-formation of 0.2~0 or 0.5~ or some other small, preselected, amount in a body. Approximately equal to the elastic and proportional limits of the material; a little higher than the proof strength of a bolt.