Torque Tension Control

Coating Lubricity or Torque Tension

As efforts are made to use a fastener at its ultimate capacity, to economise on fastener size, strength and numbers used, the lubricity of the fastener assumes a great importance.

The aim of any fastener engineer using a fastener in a normal tensile joint would be to be able to tighten similar fasteners to give a uniform known tension.

The factors that control this are:

1.Accuracy of applying and monitoring the tightening torque.
2.Underhead dimensions, surface roughness and lubricity performance of coating.
3.Conditions (and coating) of the surface which is being turned against the bearing surface i.e the surface under the head of a bolt or nut when tightened
4.The thread condition and coating lubricity.
5.The mating thread condition and coating.

The main criteria is that the variables outlined above are acceptably controlled. The specifications for the manufacture and mechanical performance of fasteners will usually control the fastener variability satisfactorily, e.g.ISO 68, ISO 724, ISO 898, ISO 965, ISO 6157 and the coating lubricity can be controlled by process control and testing according to test requirements such as BS 7371 Pt. 2 or ISO 16047.

Lubricity of Coatings

This can be expressed in two ways, the Coefficient of Friction μ and the Torque Coefficient (K factor). The figures are not the same and it is important that they are not confused with each other. The coefficient of friction takes into account many more parameters to give a more accurate result.

$$\text{Torque Coefficient } K = \frac{\text{Torque (Nm)}}{\text{Induced load (kN) x Nominal diameter (mm)}} = \frac{T}{F.d}$$

It is seen that this uses the dimension d, so the validity of K-factor is limited to fasteners of normal diameter d, so calculations using K can only accurately be used with the same dimension fastener.
The coefficient of friction μ is usually derived from the work of Kellermann and Klein[1]

$$\mu_{tot} = \frac{T/F - P/2\pi}{0.577d_2 + 0.5\,D_b}$$

Where T is the tightening torque (Nm)
F is the clamp force (kN)
P is the pitch of the thread (mm)
d_2 is basic pitch diameter of thread (mm)
Db is effective diameter of bearing surface under nut or bolt head (mm)

This is μ_{tot} which is the sum of the effective coefficient of friction on the bearing surface (μ_b) (e.g. under the head of a bolt or the rubbing surface of a nut if the nut is turned) and in the thread (μ_{th}). These figures will vary as contact materials change.

Coefficient of friction between bearing surfaces

$$\mu_b = \frac{2\,T_b}{D_b F}$$

Where T_b is torque to overcome bearing surface friction (Nm).

Coefficient of friction between threads

$$\mu_{th} = \frac{\dfrac{T_{th}}{F} - \dfrac{P}{\pi}}{0.577\,d_2}$$

T_{th} this torque required to overcome thread friction and induce tension F (kN).

It should be noted that in a typical joint the energy is divided approximately

Overcoming thread friction μ_{th}	40%
Overcoming bearing friction μ_b	50%
Producing clamp force F	10%

Changes in friction have a large effect on clamping force

To monitor coating lubrication performance, it is customary and usually considered only necessary to consider μ_{tot}. Sophisticated equipment is required to measure thread or bearing torque requirements separately which is useful to assess the effects of varying bearing surface or thread contact materials. Anochrome Group has purchased this type of equipment and has assessed the individual coefficients of friction for popular material combinations which are quoted in the table below. This can be used as a guide to compute tightening torques, but it should be considered that variations may occur. Changes to any of the parameters, or contamination of contacting surfaces, can significantly alter characteristics.

Types of Coating

Lubricated coatings fall into two categories:

1.**Integral lubricated coatings**- where the lubricant is part of the coating and is found distributed throughout the coating.

2.**Surface lubrication**- in this case, the lubricity is given by an impregnated surface coating or a wax or oil.

In some cases, to give the required performance, both types of coatings are required, type 2 on top of type 1.
The integral lubricated type is usually regarded as the better as it is easier to apply, does not require an extra coat, cannot be omitted,and its performance is more consistent in that on reuse, the coating will still be able to supply lubrication to the joint.

Most zinc flake coatings have a lubricated top coat, others have integral lubrication properties such as Geomet®500 and Dorken®KL105 which has a lubricant throughout the coating.

Electroplated coatings and some other coatings are not normally supplied with an integral lubricant so surface lubricants are used.

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Performance Enhancing Lubricants / Waxes

These coatings are often more economical than the resin bonded dry film lubricants (see below) and can be applied to a large number of standard finishes. Typical lubricants/waxes that can be applied are:

- Rustarest - Oil
- Gleitmo®
- Torque N Tension 11 or 15
- A3 Wax
- Wax 47/60

In a number of cases, A3 wax has been used to give the lubricity performance of cadmium under high pressure applications. Also similar waxes have been used to ensure that self drilling screws can give their desired performance.

In some instances, e.g. to dampen noise when inserting certain types of thread locking screw, the wax can be applied only to a portion of the thread of a fastener. (See pages Thread waxes).

Corrosion Resistance

The oils applied, though they have a disadvantage of being slightly wet, have the attraction that their mobility can enhance the corrosion resistance, particularly when components are damaged in assembly. This is not usually the case with waxes because as they are dry films, they can sometimes suffer damage, although Anochrome Group does not use any standard materials that will detract from the corrosion resistance of the original coating.

Dry Film Lubricants

The Engineer's demand for lower closely controlled friction coefficients, with no extruded material, has produced a requirement to eliminate molybdenum bearing greases and oils. The dry films used to replace these having the advantage of being tenaciously bonded to the surface giving improved reproducible performance over wide variations of temperature and under very adverse conditions. A major use of these materials is on stainless steel, to stop galling.

Dry film lubricants usually consist of a resin, used to bond a dry lubricant on to the surface of a component. The lubricants used are, in the main,P.T.F.E., Molybdenum Disulphide or Graphite, either individually or combined, to impart any of the following attributes.

- Low coefficients of friction.
- Good performance under high surface pressure conditions.
- High temperature, low temperature performance.
- Reusability.

A number of these lubricants supplied as standard by the Anochrome Group, which include Torque Tip 28(TT28), Molykote 321®, Molydag709®, Molydal 1870®and other lubricants and blends according to the requirement of the part.

The typical applications of these products are on:

•Turbo charger bolts.•Carburettor parts.•Lock parts.•Hinge pins.•Seat belt bolts and parts.•Brake and clutch pivots.•Bolts with special locking features.•High temperature nuts.•Clutch locking rings.•Machine slides.•Gearbox input shafts.•Stainless steel threads.

If necessary, these coatings can be applied to local areas of components.

In most cases these coatings will enhance corrosion resistance if applied as a top coat and also have corrosion resistance properties in their own right.

These coatings can be applied in bulk, on parts up to 0.5 kg. wt.or 150 mm long. Longer parts can be spray coated or selectively coated on the thread or underhead feature.

Re-use of Fasteners

Interest is being shown in the torque tension performance of fasteners when they are re-used and our equipment has been used to investigate the change in performance during 10 re-usecycles. In these cases, the integral lubricants show a vast improvement over the "surface" type of torque tension control (See charts below).

If required, please contact us for further information on the torque tension performance of coatings.

Torque Tension Perfomance Data

Data for guidance is given on the following graphs, but it should be noted that the actual component that is coated, its dimensions and the coating dimensions of mating parts can have a significant effect on the actual tightening performance.

Most figures have been obtained from testing parts that conform to the ISO specification for coarse series of bolts and in many cases M10 flange fasteners have been used.

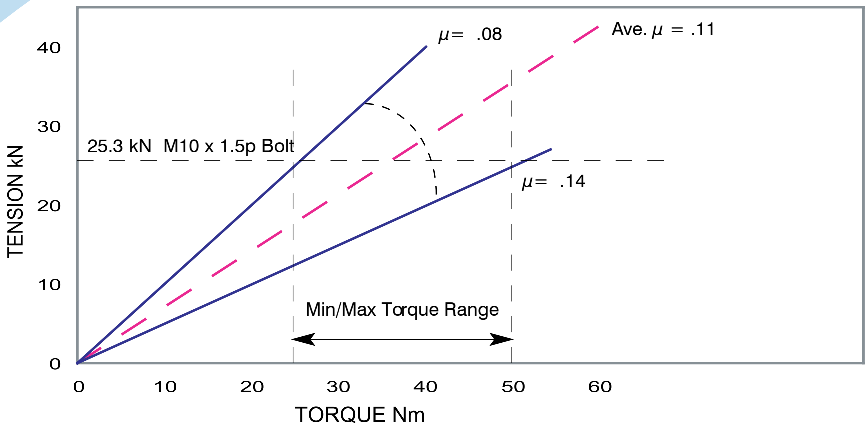
Anochrome Group

Inlex Locking Ltd
Wood Lane, Fordhouses, Wolverhampton WV10 8HN
tel: 01902 397300 fax: 01902 785372
enquiries@anochrome-group.co.uk
www.anochrome.co.uk

Torque Tension Conrol

Typical Torque Tension Specification Requirements

BAND A

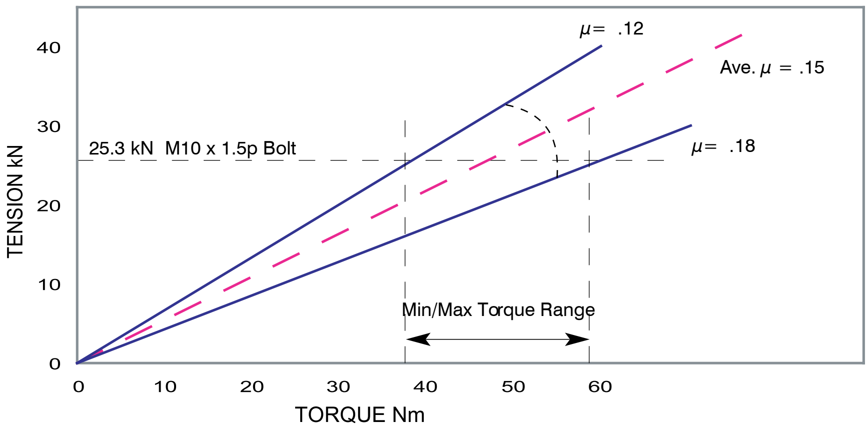


Specifications that fall within Band A

VW TL 246
OPEL GME 00255
MERCEDES
BMW GS 90010
GM 3359
HONDA D2008-5

Materials
DELTAPROTEKT®+VH 301GZ
GEOMET®321 +VL

BAND B

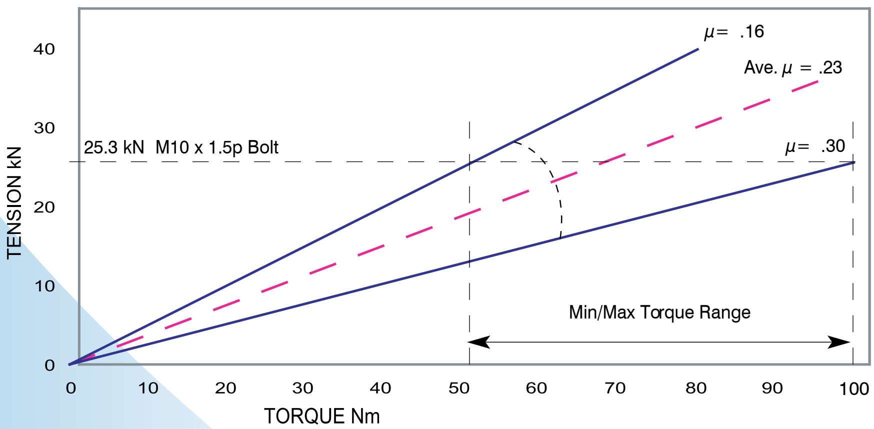


Specifications that fall within Band B

FORD WZ100 (μ= .12 - .18) (S438, S447, S448)
FORD WZ101 (μ= .11 - .17)(S439, S440, S442)
RENAULT 01-71-002/- -Q
PEUGEOT/CITROEN B152230

Materials
DELTAPROTEKT®+ VH 302GZ
GEOMET®321
GEOMET®500
GEOBLACK®
MAGNI 565 & 560

BAND C



Specifications that fall within Band C

HONDA
FORD S4

Materials
UNLUBRICATED ZINC
UNCOATED UNLUBRICATED BOLT
ZINC NICKEL

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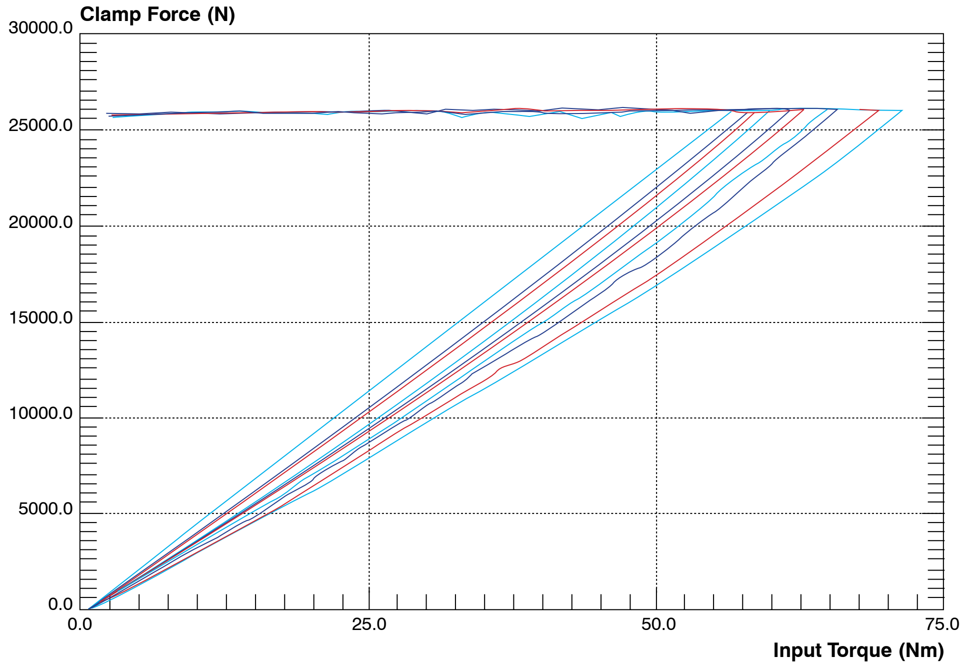
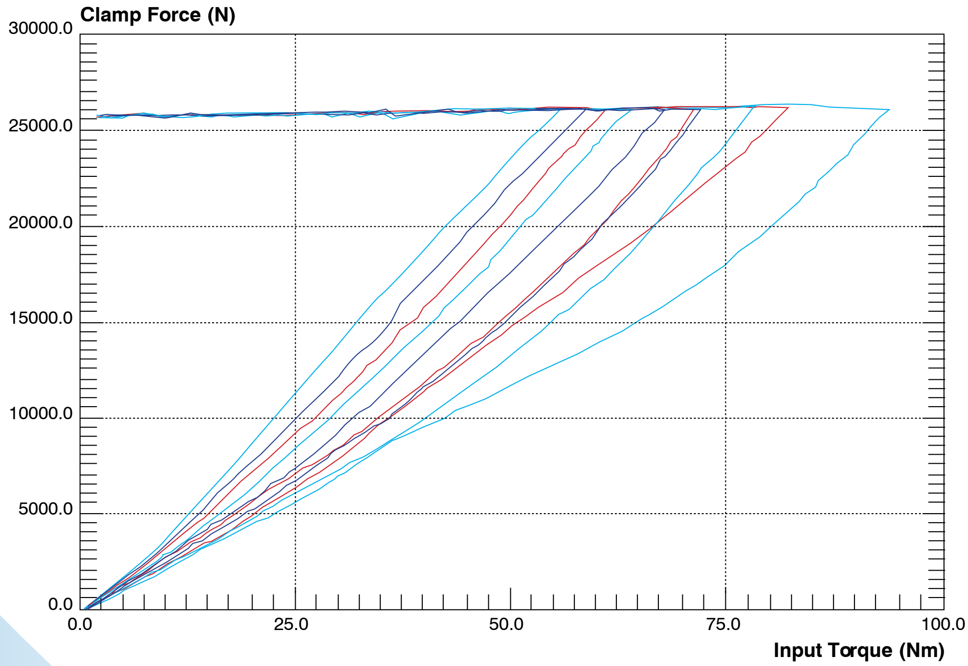
Integral Lubricant. Typical - Zinc Flake Re-use



Surface Lubricant. Typical -Zinc Electroplate + lube Re-use



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Typical Performance Data for Coatings with Standard Lubrication

TABLE1. CLAMPING FORCES & APPLIED TORQUE-BOLTS AND NUTS (ISO METRIC FASTENERS)												
	CLAMPING FORCE kN				APPLIED TORQUE Nm							
	PROPERTY CLASS				PC 8.8 / 8		PC 9.8 / 9		PC 10.9 / 10		PC 12.9 / 12	
	8.8/8	9/8/9	10/9/10	12.9/12	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
M3	2.2	-	3.1	3.7	1.1	1.6	-	-	1.4	2.2	1.7	2.6
M4	3.8	-	5.5	6.4	2.5	3.7	-	-	3.7	5.3	4.0	5.7
M5	6.2	6.9	8.9	10.4	5.0	7.4	5.6	8.2	7.2	106	8.0	11.6
M6	8.7	9.8	12.5	14.6	8.4	12.4	9.5	14.0	12.1	17.8	13.5	19.5
M8	15.9	17.8	22.8	26.6	20	30	23	34	29	43	33	47
M10	25.3	28.3	36.1	42.2	41	60	46	68	59	85	65	94
M12	36.7	41.1	52.5	61.4	71	105	80	118	102	150	114	164
M14	50	56.1	71.6	84	112	168	127	187	161	240	182	265
M16	68.2	76.5	97.5	114	175	260	198	292	250	371	282	406
M18	86.2	-	119	140	255	372	-	-	353	513	390	560
M20	110	-	152	178	355	520	-	-	491	718	550	795
M22	136	-	189	220	500	705	-	-	675	989	750	1080
M24	159	-	220	256	620	928	-	-	857	1283	950	1370

NOTE: The Clamping Forces specified are equal to 75% of the proof load of the property classes of bolts as given in ISO 898/1.The Applied Torque figures are test requirements and are not recommended for use as assembly data.Thread locking and sealing features generally perform to this table. Please contact us for confirmation.This table complies with BS7371 Pt 2. Ford WZ100. Testing to Ford WZ101 is also available.Testing to International Standards such as ISO 16047 is recommended in the absence of customer standards.

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