Local Representative WI & U.P. of MI: **Centerline, Inc.**
920.730.0615
info@ctrline.net
www.ctrline.net

THE IMPORTANCE OF APPLYING PROPER TORQUE VALUES

Drive trains being misaligned is a common phenomenon in plants around the globe. Luckily the majority of industries invested in alignment tools and training to minimize the parallel and angular offsets in machine trains. It affects the lifetime of assets, reduces power consumption and optimizes production capabilities.

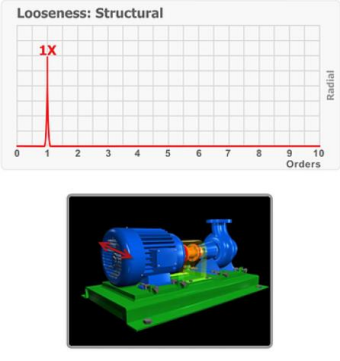
SYMPTOMS

It is not always easy to detect misalignment on machinery that is running. The radial forces that are transmitted from shaft to shaft are challenging to measure externally. By using vibration analysis or infrared thermography, it is possible to identify primary symptoms of misalignment such as high vibration readings in radial and axial directions or abnormal temperature gradients in machine casings. Still, without such instrumentation, it is also possible to identify secondary machine problems, which can indicate inaccurate shaft alignment.

CAUSES OF MACHINE BREAKDOWN

- Loose or broken foundation bolts
- Loose shim packs or dowel pins
- Excessive oil leakage at bearing seals
- Loose or broken coupling bolts
- Some flexible coupling designs run hot when misaligned
- If the coupling has elastomeric elements, look for rubber powder inside the coupling shroud
- Similar pieces of equipment are vibrating less or have a longer operating life
- An unusually high rate of coupling failures or wear
- An excessive amount of grease or oil inside coupling guards
- Shafts are breaking or cracking at or close to the inboard bearings or coupling hubs

There are many aspects to machine alignment, such as the understanding of what it means when the centerlines of shafts are not collinear, the proper shimming, what is a soft foot, what kind of coupling types exist, what are the tolerances and best practices. One other major factor in the appropriate machine installation and alignment is the torque that is applied to the hold-down bolts.



Hold-down bolts need to be torqued each time in the right sequence to avoid that the bolts are too tight or too loose. Otherwise, fasteners can break, or increased vibration occurs. The looseness is usually picked up by the vibration team. (1x and occasionally its harmonics as shown in image to the left - *image courtesy of Mobius Institute*).

It is imperative that the clamping forces are as even as possible during the soft foot measurements but also during and after the actual alignment process.

WHAT IS THE RECOMMENDED TARGET TORQUE

The target torque depends on many factors. An OEM should have specified the values originally. If not, one needs to go by the grades of the bolts, thread type and nut factor. Each fastener grade has specific limits based on the strength of its material. The usual grades are 5 or 8.

HOW TO IDENTIFY FASTENER/BOLT GRADES/THREAD SIZE/NUT FACTOR?

The grade can easily be determined via the grade markings on the bolts, as shown in the chart. Grade 5 has three lines, and Grade 8 has six lines on its head. The bolt grade must be identified correctly.

Since now the grade is determined, what is the recommended target torque value?

There is another factor that plays a role in identifying the proper target torque. The thread size needs to be considered, too.

Coarse threads are those with larger pitch (fewer threads per axial distance), and fine threads are those with smaller pitch (more threads per axial distance). Coarse threads have a larger thread form relative to the bolt diameter, where fine threads have a smaller thread form relative to bolt diameter.

Grade	Radial Bolt Markings	Material	Nominal Size Diameter/Inches	Proof Load psi	Tensile Strength minimum psi	Yield Strength minimum psi
Grade 2 No Radial Lines		Low or Medium Carbon Steel	1/4" to 3/4"	55,000	74,000	57,000
			Over 3/4" thru 1 1/2"	33,000	60,000	36,000
Grade 5 3 Radial Lines		Medium Carbon Steel	1/4" to 1"	85,000	120,000	92,000
			Over 1" thru 1 1/2"	74,000	105,000	81,000
Grade 8 6 Radial Lines		Medium Carbon Alloy Steel	1/4" thru 1 1/2"	120,000	150,000	130,000
Metric 8.8		Medium Carbon Steel	All sizes under 16mm	580	800	640
			16mm thru 72mm	600	830	660
Metric 10.9		Alloy Steel	5mm thru 100mm	830	1040	940

Lastly, the nut factor, K, sums up the combined effects of many variables affecting the difficulty of tightening the bolt, such as friction.

Some of these factors include:

- The type and material of the bolt, washer and nut
- The presence and nature of any plating, coating or lubrication
- The pitch or angle of the bolt threads
- Corrosion and wear

Often, field operations personnel will use the chart included with a torque wrench to determine the amount of torque they should apply to a bolted joint to get the right amount of tension. However, these torque charts typically are based on the assumption that K=0.2 and experiments show that this assumption often may not be accurate.

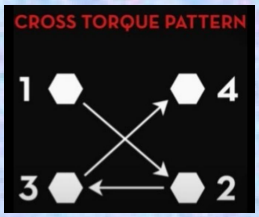
Since we have now reviewed the three factors, one can find the right torque target in published torque tables.

As an example, a 1-1/4 inch bolt grade 8 (K = 0.2) with a fine thread has a recommended torque target of 2,012 ft-lbs according to the Fastenal Tightening chart shown below.

TORQUE-TENSION RELATIONSHIP FOR A307A, GRADE 5, 8 & 9 BOLTS

Nominal Dia. (in.)	Threads per inch	ASTM A307 Grade A				SAE J429 Grade 5					SAE J429 Grade 8					FNL Grade 9				
		Clamp Load (Lbs.)	Tightening Torque			Clamp Load (Lbs.)	Tightening Torque				Clamp Load (Lbs.)	Tightening Torque				Clamp Load (Lbs.)	Tightening Torque			
			K = 0.15	K = 0.17	K = 0.20		Ecoguard™	K = 0.15	K = 0.17	K = 0.20		Eco-guard™	K = 0.15	K = 0.17	K = 0.20		Eco-guard™	K = 0.15	K = 0.17	K = 0.20
Coarse Thread Series																				
1/4	20	859	32 in-lbs	37 in-lbs	43 in-lbs	2029	61 in-lbs	76 in-lbs	86 in-lbs	10 1in-lbs	2864	86 in-lbs	107 in-lbs	122 in-lbs	143 in-lbs	3357	101 in-lbs	126 in-lbs	143 in-lbs	168 in-lbs
5/16	18	1416	66	75	88	3342	125	157	178	209	4719	177	221	251	295	5531	207	259	294	346
3/8	16	2092	10 ft-lbs	1 1 ft-lbs	13 ft-lbs	4940	19 ft-lbs	23 ft-lbs	26 ft-lbs	31 ft-lbs	6974	26 ft-lbs	33 ft-lbs	37 ft-lbs	44 ft-lbs	8174	31 ft-lbs	38 ft-lbs	43 ft-lbs	51 ft-lbs
7/16	14	2870	16	18	21	6777	30	37	42	49	9568	42	52	59	70	11214	49	61	70	82
1/2	13	3831	24	27	32	9046	45	57	64	75	12771	64	80	90	106	14969	75	94	106	125
9/16	12	4912	35	39	46	11599	65	82	92	109	16375	92	115	130	154	19193	108	135	153	180
5/8	11	6102	48	54	64	14408	90	113	128	150	20340	127	159	180	212	23840	149	186	211	248
3/4	10	9030	85	96	113	21322	160	200	227	267	30101	226	282	320	376	35281	265	331	375	441
7/8	9	12467	136	155	182	29436	258	322	365	429	41556	364	455	515	606	48707	426	533	604	710
1	8	16355	204	232	273	38616	386	483	547	644	54517	545	681	772	909	63899	639	799	905	1065
1-1/4	7	26166	409	463	545	53786	672	840	952	1121	87220	1090	1363	1545	1817	102229	1278	1597	1810	2130
1-3/8	6	31182	536	607	715	64096	881	1102	1249	1469	103939	1429	1768	2025	2382	121826	1675	2094	2373	2792
1-1/2	6	37942	711	806	949	77991	1170	1462	1657	1950	126473	1897	2371	2688	3162	148237	2224	2779	3150	3706
Fine Thread Series																				
1/4	28					2319	70 in-lbs	87 in-lbs	99 in-lbs	116 in-lbs	3274	98 in-lbs	123 in-lbs	139 in-lbs	164 in-lbs	3837	115 in-lbs	144 in-lbs	163 in-lbs	192 in-lbs
5/16	24					3702	139	174	197	231	5226	196	245	278	327	6125	230	287	325	383
3/8	24					5599	21 ft-lbs	26 ft-lbs	30 ft-lbs	35 ft-lbs	7905	30 ft-lbs	37 ft-lbs	42 ft-lbs	49 ft-lbs	9265	35 ft-lbs	43 ft-lbs	49 ft-lbs	58 ft-lbs
7/16	20					7568	33	41	47	55	10684	47	58	66	78	12523	55	68	78	91
1/2	20					10197	51	64	72	85	14396	72	90	102	120	16873	84	105	120	141
9/16	18					12940	73	91	103	121	18268	103	128	146	171	21412	120	151	171	201
5/8	18					16317	102	127	144	170	23036	144	180	204	240	27000	169	211	239	281
3/4	16					23776	178	223	253	297	33566	252	315	357	420	39343	295	369	418	492
7/8	14					32479	284	355	403	474	45853	401	502	568	669	53743	470	588	666	784
1	14					43343	433	542	614	722	61190	612	765	867	1020	71720	717	896	1016	1195
1-1/4	12					59548	744	930	1055	1241	96565	1207	1509	1710	2012	113182	1415	1768	2004	2358
1-3/8	12					72967	1003	1254	1421	1672	118324	1627	2034	2305	2712	138686	1907	2384	2701	3278
1-1/2	12					87747	1316	1645	1865	2194	142282	2134	2668	3024	3557	166778	2502	3127	3544	4169

Tightening Torque Table – Courtesy of Fastenal

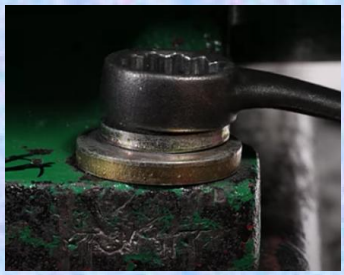


TORQUE SEQUENCE

It is recommended to use a cross torquing pattern, as shown in the image to the right. Two to three passes are suggested.

BOLTING TOOLS

Depending on the size of the motor and the desired target torque values, different methods can be used to induce the appropriate force.



1. Ring Spanner - Wrench

The most popular system to tighten bolts is a standard wrench or ring spanner, especially on smaller standard motors and machine trains. There is, however, no control of how tight the bolts are tightened.

2. Mechanical or Digital Torque Wrench

In most instances, a socket wrench with unique internal mechanisms is recommended and used. It allows the operator to set the torque applied to the fastener so it can be matched to the specifications. There is a limit in the maximum torque that can be achieved.

3. Manual Torque Multipliers

If higher torque values are required, there is the possibility of using manual or offset multipliers in combination with a mechanical or digital torque wrench. These tools are easy to use, economical and require little training.

4. Electric/Battery/Pneumatic Torque Multipliers

An elegant method is the use of an electric or air-powered multiplier. In case of obstruction at the motor feet, which is most of the time the case, they can be used in combination with an offset multiplier due to the low profile requirements, as shown below. The input of the torque multiplier is clearly defined. It is multiplied with the ratio of the offset multiplier, which allows users to set the precise and accurate torque output throughout the process with excellent repeatability and accuracy.

The offset multiplier is the ultimate answer for gaining access where standard multipliers are too tall or bulky to fit the application and they can be combined with a battery multiplier for low-profile applications.

5. Hydraulic Tightening

Due to the low profile requirements, hydraulic torque wrenches are popular. The torque is set on the manometer of the pump and precisely defined by the torque chart that applies to the used hydraulic wrench.

Benefits and special features of hydraulic wrenches:

- Flat design
- Torque accuracy not affected by interference from lateral forces

CONCLUSION

There are many things to consider when doing an installation and alignment of drive trains, and frequently the proper torquing of the hold-down bolts and flanges of attached pipes (pipe strain) are neglected. Identify target values if not provided by OEM. Select the appropriate torque tool. Apply repeatable and accurate torque values to assure precise results. Use the Cross Torque Pattern Method to ensure even distribution.

Applying the right torque with an adequate tool is one of the many required steps to optimize the operation of machine trains!