

18. KSP



W. S. DARLEY & CO.

REPAIR SERVICE INSTRUCTIONS

TYPE KSP PTO FIRE PUMP

TO REMOVE KSP PUMP AND TRANSMISSION FROM TRUCK CHASSIS

1. Remove the following from the pump:

- Primer Tubing
- Gage Line Tubing
- Auxiliary Cooling Lines
- Tachometer Cable

2. Drain oil from transmission case.

3. Remove universal joint from transmission shaft (19).

4. Support the pump from the bottom with blocks or a floor jack.

5. Remove eight 3/8" NC cap screws holding suction manifold to suction fitting (2), or remove Victaulic coupling if so equipped.

6. Remove eight 3/8" NC nuts holding volute (1) to companion flange (17).

7. Remove four 3/8" NC cap screws holding transmission case to mounting brackets on truck chassis.

8. Lower pump and transmission out of truck chassis.

KSP PTO PUMP DISASSEMBLY FOR OVERHAUL

REFER TO DRAWING DKC0302

1. Remove twelve 3/8" NC nuts and remove suction fitting (2) from volute (1).

2. If necessary to remove, tap seal ring (6) out of suction fitting (2) and remove o-ring (5).

3. Remove cotter key (26), impeller nut (7) and impeller washer from impeller shaft (4).

4. Slide impeller (3) off of impeller shaft (4).

5. Remove four 5/16" NC cap screws and remove bearing cap (23). Two 5/16" NC tapped holes in flange with facilitate separation.

6. Remove two 3/8" NC cap screws and two 3/8"NC nut from studs and remove volute (1) and impeller shaft/pinion gear assembly from transmission case (20).

7. Slide impeller shaft (4) out of volute.

8. If necessary to replace, pull or pry seal ring (6) out of volute (1).

9. Press oil seal (40) out of volute(1).

10. If necessary to replace, press stuffing box (9) out of volute(4). Remove old packing (10) from stuffing box and plunger guide.

11. Press bearing (27) off of impeller shaft (4).

12. Pry tab of lock washer (30) out of slot in lock nut (29). Remove lock nut and lock washer from impeller shaft (4).

13. Press pinion gear (62) off of impeller shaft (4). Remove key (31) and spacer (34). Mark bearing side of gear with center punch.

14. Press bearing (28) off of impeller shaft (4).

15. Remove three 5/16" NC cap screws and remove bearing cap (25).

16. Remove three 5/16" NC cap screws and remove bearing cap (24).

17. Press oil seal (11) out of bearing cap (24).
 18. Tap two dowel pins out of transmission case (20) and transmission case cover (21) from cover side. Remove eight 5/16" NC socket head cap screws, and remove transmission case cover (21) from transmission case (20).
 19. Remove transmission shaft/drive gear from transmission case (20).
 20. Press tachometer worm gear (32) off of transmission shaft (19), (if so equipped). Remove woodruff key (41).
 21. Press transmission shaft (19) out of drive gear (63), spacer (34), and bearing (28) all at once.
 22. Press rear bearing (28) off of transmission shaft (19).
- If tachometer disassembly is required:
23. If tachometer driven gear (33) is pinned, tap out drive lock pin (42).
 24. Tap or press tachometer shaft (36) out of tachometer driven gear (33) and bearing (39). Remove tachometer gear.
 25. Press or tap tachometer bearings (39) out of bearing cap (24).

PUMP PARTS INSPECTION AND MEASUREMENT

1. Clean all parts and examine carefully for wear or deterioration. Replace any questionable parts.
2. Measure the impeller seal rings and impeller for wear. Use the following tape for comparison.

Impeller Seal Ring O.D.	5.753 - 5.755"
Impeller Seal Ring I. D.	5.504 - 5.506"
Seal Ring O.D.	5.768 - 5.770"
Seal Ring I.D.	5.489 - 5.491"
Clearance O.D. - original	0.013 - 0.017"
Clearance I.D. - original	0.013 - 0.017"
3. If the clearance exceeds 0.025" on diameter, impeller seal ring can be restored to original size by soldering a ring over trued surface which retains at least 0.090" wall thickness. Stationary seal rings (6) should also be replace.
4. Measure stuffing box and impeller shaft for wear. Use the following table for comparison.

Impeller shaft diameter at packing area	1.303 - 1.304"
Stuffing box bore - new	1.312 - 1.313"
Stuffing box - max.	1.318"
Clearance - original	0.008 - 0.010"
Clearance - maximum	0.015"
5. Measure bearing housing bores for proper size. Use the following table for comparison. If any bore exceeds the high limit by 0.0005", the part should be replaced.

PART	REP. NO.	ORIGINAL BORE DIAMETER
Volute	1	3.1496 - 3.1503"
Bearing cap	23	2.0472 - 2.0480"
Bearing cap	24	3.1496 - 3.1503"
Bearing cap	25	3.1496 - 3.1503"
Transmission case	20	3.1496 - 3.1503"
Transmission case cover	21	3.1496 - 3.1503"

6. Measure shaft bearing journals for proper size. Use the following table for comparison. Low limit under bearings is required to insure a press fit with inner ball bearing race.

PART	REP. NO.	ORIGINAL JOURNAL DIA.
Impeller shaft	4 small	0.7874 - 0.7878"
	large	1.3781 - 1.3785"

7. The original impeller shaft diameter under the pinion gear is 1.3781 -1.3785". The original pinion gear bore is 1.3785 - 1.3790" providing 0.0000 - 0.0009" clearance. The parts are still serviceable up to 0.0014" clearance. Pinion gear may be reversed to work other side of gear teeth.
8. The original transmission shaft diameter under the drive gear is 1.781 - 1.3785". The original drive gear bore s 1.3781 - 1.3785" providing 0.0004 inch press fit to 0.0004" clearance. The parts are still serviceable up to 0.0009" clearance. Drive gear may be reversed to work other side of gear teeth.

ASSEMBLY OF KSP PTO PUMP

Refer to Drawing DKC0202

1. Apply a light coating of grease to transmission shaft (19). Place key (31) in transmission shaft keyway, align with keyslot in drive gear (63), and press shaft into drive gear bore until shaft shoulder is tight against side of gear.
2. Slide spacer (34) onto transmission shaft (19). Apply a light coating of grease to bore of bearing (28) an press bearing evenly onto shaft until inner race of bearing, spacer, and drive gear are tight together.
3. If equipped with tachometer, place woodruff key (41) in its groove in transmission shaft (19). Apply a light coating of grease to bore of tachometer worm gear (32) and press onto transmission shaft.
4. Apply a thin layer of Loctite 518 or equivalent to gasket flange surface of bearing cap (25) an place gasket (35) in position on bearing cap against Loctite 518 or equivalent surface.
5. Attach bearing cap to transmission case (20) with three 5/16" NC x 3/4" cap screws and lock washers, but do not tighten cap screws.
6. Insert transmission shaft/drive gear assembly into transmission case (20), making sure rear bearing (28) is in its bore.
7. Apply a thin layer of Loctite 518 or equivalent to gasket flange surface of transmission case cover (21) and place gasket (22) in position on cover against Loctite 518 or equivalent surface.
8. Locate transmission case cover(21) to transmission case (20) with two 5/16" dowel pins. Tap pins in from transmission case side. Attach cover to case with eight 5/16" NC x 1" socket head cap screws and lock washers.
9. Press oil seal (11) into bearing cap (24) with lip spring of seal facing bearing. Fill grease cavity with grease and lubricate oil seal lips.

If tachometer drive shaft has been disassembled, follow steps 10 through 15.

10. Press bearing (39) into bearing cap (24) flush with inside of gear pocket.
11. Ream bearings (39) with a 5/16" x 4" (or longer) ream.
12. Place tachometer driven gear (33) in pocket between bearings (39).
13. Press or tap tachometer shaft (36) through bushing (39) and into driven gear (33) with square key hole and facing tachometer cable pocket.
14. On newer style of tachometer shaft, tap a 3.32" x 7/16" drive lock pin (42) into tachometer driven gear (33) and tachometer shaft (36).

15. Make sure gear and shaft rotate freely.
16. Apply a thin layer of Loctite 518 or equivalent to gasket flange surface of bearing cap (24), and place gasket gear (35) in position on bearing cap against Loctite 518 or equivalent surface.
17. Attach bearing cap (24) and gasket (35) to transmission case cover (21) with three 5/16" NC x 3/4" cap screws and lock washers.
18. Tighten cap screws holding bearing cap (25).
19. Slide spacer (34) onto impeller shaft (4).
20. Apply a light coating of grease to impeller shaft (4). Place key (31) in impeller shaft keyway, align with keyslot in pinion gear (62), and press shaft evenly into pinion gear bore until shaft shoulder, spacer, and pinion gear are tight together.
21. Slide a lock washer (30) onto impeller shaft (4) and install lock nut (29). Tighten lock nut until a tab of lock washer aligns with a slot on lock nut. Press tab of lock washer into slot on lock nut.
22. Apply a light coating of grease to bore of bearing (28), and press bearing onto shaft (4) until tight against shaft shoulder.
23. Apply a light coating of grease to bore of bearing (27), and press bearing onto shaft (4) until tight against shaft shoulder.
24. Align packing guide hole in stuffing box (9) with hole in volute(1). Press stuffing box into volute until seated.
25. Press seal ring (6) into volute (1) until seated.
26. Press oil seal (40) into volute (1) with lip spring of seal facing bearing. Fill grease cavity with grease and lubricate oil seal lips.
27. Apply grease to water slinger (69) and place in position on oil seal (40).
28. Insert impeller shaft/pinion gear assembly into volute (1). Slide water slinger (69) into its groove on impeller shaft.
29. Apply a thin layer of Loctite 518 or equivalent to gasket flange surface of volute(1).
30. Insert impeller shaft/pinion gear into transmission case (20) and place volute (1) in position on transmission case. Attach volute to transmission case with two 3/8" NC x 1-1/4" cap screws and lock washers and two 3/8"NC nuts and lock washers on studs.
31. Apply a thin layer of Loctite 518 or equivalent to gasket flange surface of bearing cap (23), and place gasket (58) in position on bearing cap against Loctite 518 or equivalent surface.
32. Attach bearing cap (23) to transmission case cover (21) with four 5/16" NC x 7/8" cap screws and lock washers.
33. Slide impeller (3) onto impeller shaft (4). Place impeller washer (8) on shaft.
34. Clean and dry shaft thread and impeller nut (7), removing dirt, grease and oil. (Loctite Klean N' Prime Part No. 2556, can be used to clean parts and shorten cure time.)
35. Apply Loctite 243 or equivalent Threadlocker to shaft thread and nut thread.

36. Tighten impeller nut (7) until it contacts with impeller washer (8), then turn to the next cotter key hole.
(DO NOT OVER TIGHTEN.)
37. Install a 1/8" x 1" STAINLESS STEEL cotter key (26) in impeller shaft cotter key hole.
38. Press seal ring (6) into suction fitting (2).
39. Apply a silicon lubricant, such a Dow Corning Compound 111 (or equivalent), to o-ring(5) and place in position on suction fitting (2).
40. Attach suction fitting (2) to volute (1) with twelve 3/8" NC nuts on studs.

INSTALLING PUMP IN TRUCK CHASSIS

Reverse the procedures outlined under removal instructions.

Lubricate universal joint slip yoke on pump drive shaft.

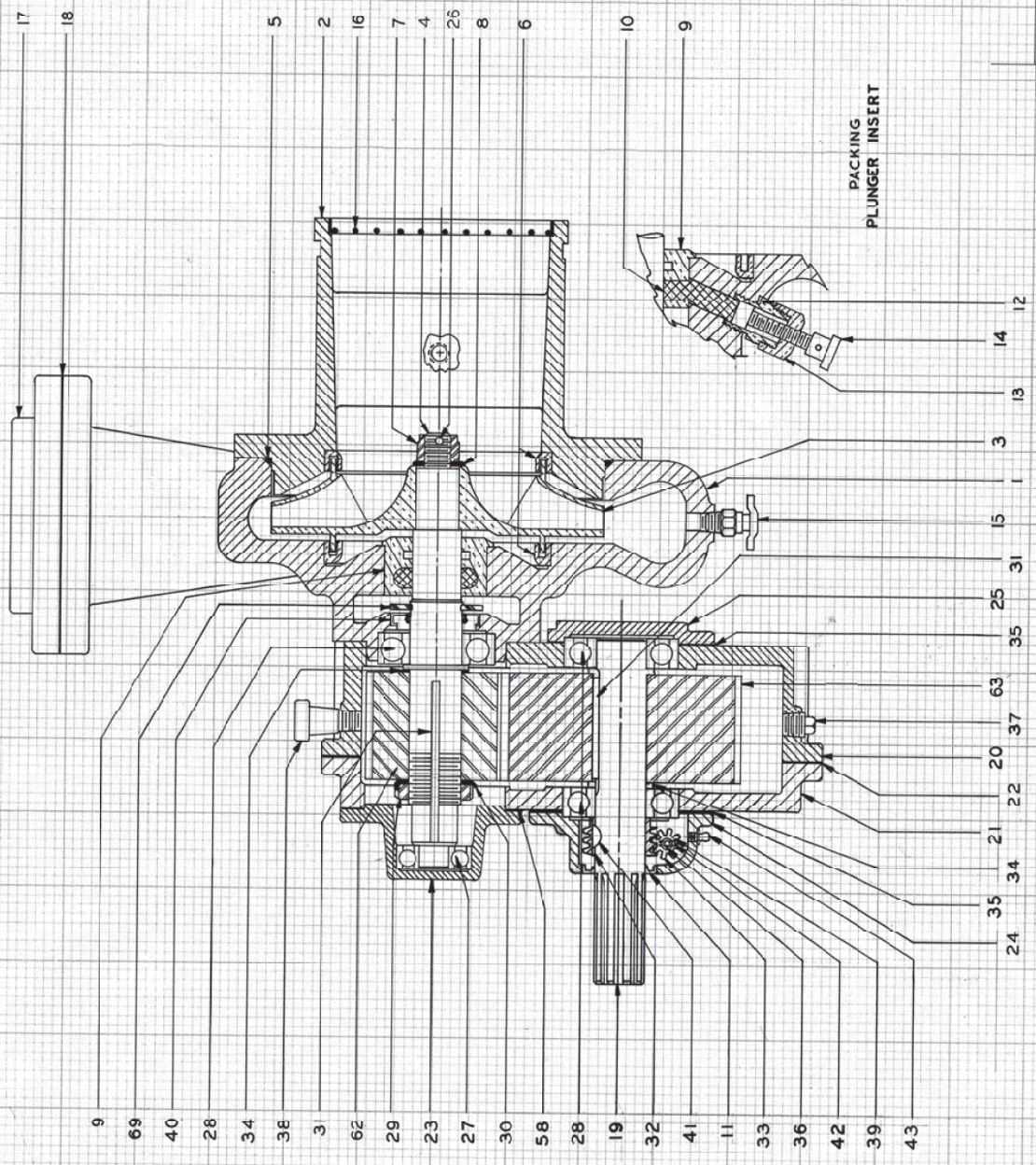
Fill gearcase with SAE 80W/90 Gear Lube Oil to the level of the oil-level plug on the gearcase cover.

DO NOT OVERFILL.

Maintain the pump transmission oil level every 25 hours, or 3 months which ever comes first, and change the oil every 50 hours, or 6 months, which ever comes first.

Change the pump transmission oil every 50 hours, or every 6 month, which ever comes first.

**IF FURTHER INFORMATION IS NEEDED, CALL W.S. DARLEY & CO. AT
CHIPPEWA FALLS, WI AT 800-634-7812 or 715-726-2650**



PART NO.	DATE	CHANGE
W.S. DARLEY & CO.	W.S. DARLEY & CO.	W.S. DARLEY & CO.
WELLSVILLE, OHIO	WELLSVILLE, OHIO	WELLSVILLE, OHIO
AS NOTED	AS NOTED	AS NOTED
NO. 001	NO. 001	NO. 001
REV. 001	REV. 001	REV. 001
DATE 10-19-89	DATE 10-19-89	DATE 10-19-89
DRN. S. LEE	DRN. S. LEE	DRN. S. LEE
CHKD. ...	CHKD. ...	CHKD. ...
TRD.	TRD.	TRD.
SCALE	SCALE	SCALE
OLD PART #	OLD PART #	OLD PART #
K649	K649	K649
DO NOT SCALE PRINT	DO NOT SCALE PRINT	DO NOT SCALE PRINT
MATERIAL:	MATERIAL:	MATERIAL:
ALL DIMENSIONS IN INCHES UNLESS NOTED	ALL DIMENSIONS IN INCHES UNLESS NOTED	ALL DIMENSIONS IN INCHES UNLESS NOTED
THIS DESIGN IS THE PROPERTY OF W.S. DARLEY & CO. REPRODUCTION IS PROHIBITED.	THIS DESIGN IS THE PROPERTY OF W.S. DARLEY & CO. REPRODUCTION IS PROHIBITED.	THIS DESIGN IS THE PROPERTY OF W.S. DARLEY & CO. REPRODUCTION IS PROHIBITED.

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**TYPE KSP FIRE PUMP PARTS LIST
DRAWING DKC0202**

Rep. No.	Name of Part	Qty.	Rep. No.	Name of Part	Qty.
1	Volute	1	24	Front Bearing Cap	1
2	Suction Fitting	1	25	Bearing Cap	1
3	Impeller	1	26	Cotter Key	1
4	Impeller Shaft	1	27	Bearing-Impeller Shaft	1
5	O'Ring	1	28	Bearing	3
6	Seal Ring	2	29	Locknut	1
7	Impeller Nut	1	30	Lockwasher	1
8	Impeller Shaft Washer	1	31	Key	2
9	Stuffing Box	1	32	Tachometer Worm	1
10	Packing	8	33	Tachometer Gear	1
11	Oil Seal - Transmission Shaft	1	34	Spacer	2
12	Packing Plunger Guide	1	35	Bearing Cover Gasket	2
13	Gland Nut	1	36	Tachometer Drive Shaft	1
14	Packing Plunger	1	37	Magnetic Drain Plug	1
15	Drain Cock	1	38	Gear Case Vent	1
16	Hydrant Strainer	1	39	Bearing	2
17	Companion Flange	1	40	Oil Seal-Impeller Shaft	1
18	Discharge Head Gasket	1	41	Tachometer Gear-Key	1
19	Transmission Shaft	1	42	Tachometer Gear-Pin	1
20	Transmission Case	1	43	Grease Zerk	1
21	Transmission Case Cover	1	58	Bearing Cap Gasket	1
22	Transmission Gasket	1	62	Pinion Gear	1
23	Bearing Cap	1	63	Drive Gear	1
			69	Water Slinger	1



W. S. DARLEY & CO.

DARLEY INJECTION TYPE STUFFING BOX ADJUSTMENT

⚠ Prop 65 Warning: This product contains lead, a chemical known to the State of California to cause cancer, birth defects, and other reproductive harm. Wash hands after handling.

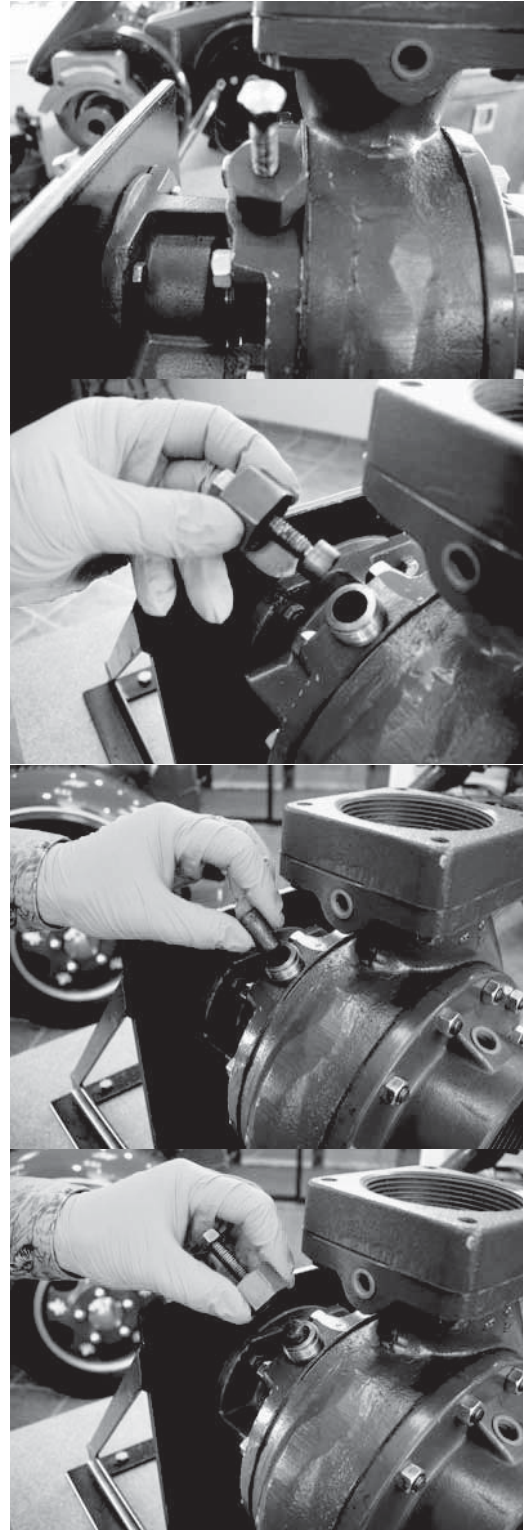
⚠ Caution: Do not attempt to use anything but Darley injection packing. Using the wrong packing material in your pump may cause catastrophic failure of the pump shaft sealing components.

Only use W.S. Darley & Co.'s plastallic injection packing material. It is made of a special composition of shredded fibers, and a special bonding and lubricating compound.

It is important that the stuffing box is completely filled solid with packing and compressed firm during adjustment to prevent formation of voids and excessive leakage.

To pack the stuffing box when empty and assembled in the pump, remove the packing screw and nut assembly, and insert pellet form packing into the packing plunger guide. Replace the packing screw assembly and use a hand speed wrench to force the pellets into the gland. **DO NOT USE A POWER TOOL!** Repeat pellet additions while turning the impeller shaft by hand until resistance to turning is felt when the stuffing box is almost full. Continue turning packing screw by hand using a standard 6" long 9/16" end wrench until 4 lb. of force is felt at the end of the wrench. This is equivalent to 2 ft-lb or 24 in-lb torque. Continue turning until a few flakes of packing are extruded out the opening between the impeller shaft and the stuffing box hole. The gland is now ready for pressure testing or pumping.

After priming the pump with water, start the pump and raise the discharge pressure to 50 psi. Tighten the packing screw using a 6" long 9/16" end wrench until 4 lb. force is felt at the end of the wrench (24 in-lb torque). Continue operating the pump at 50 psi for 5 minutes to dissipate packing pressure against the shaft and permit cooling water to flow between the shaft and stuffing box hole. Make sure that water actually does come through before operating pump at any higher pressure. The normal drip rate may vary between 5 and 60 drops per minute.



Operate the pump for 10 minutes at the highest normal operating pressure flowing sufficient water to prevent overheating. Do not run the pump blocked tight. Lower discharge pressure to 50 psi and repeat the packing screw tightening procedure outlined above.

The pump may now be operated for any time period required within its rated capacity. However, the drip rate should be monitored more frequently during the first few hours, and adjusted if necessary to achieve a stable flow rate. Several more adjustments may be required.



For a list of approximate quantity of packing pellets required by model (completely repacked), see below:

Model	Approximate # Packing Pellets
A	6
2BE	6
EM	15
H	8
JM	8
KD	10
KS	8
LD	15
LS	9
P	10
U2	5
U4	10

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at Chippewa Falls, WI. at 800-634-7812 or 715-726-2650



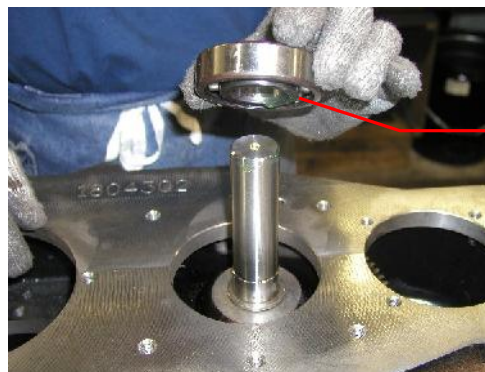
DARLEY

BASIC ASSEMBLING TECHNIQUES

- Work with clean tools in clean surroundings during assembly.
- Clean parts thoroughly and keep free from nicks and abrasions.
- Keep loose parts marked otherwise identified to avoid error in assembly.
- **Bearings:** Keep bearings in original containers until ready to install.
- **Bearings/Press fits:** Clean and oil bearing seats and other parts having press fits to prevent galling.
- **Bearings:** When pressing a bearing onto a shaft, the bearing must be started perpendicular (square) to the shaft.



- **Bearings:** When pressing bearings onto a shaft all forces applied to the bearing need to be applied to the inner race.
- **Bearings:** When pressing bearings into a pocket all forces applied to the bearing need to be applied to the outer race.
- **Bearings:** When installing a bearing with one shield, the open side goes toward the oil cavity/gear case. Typically the single shield will be next to an oil seal.



**OPEN SIDE
OF BEARING**

- **Bearings:** When pressing a bearing onto a shaft, lightly lube the bore of the bearing and the shaft journal for the bearing with oil. Also when installing bearings into bearing pockets, lightly lube the OD of the bearing and the bore of the bearing pocket with oil.



- **Bearings:** If necessary to remove a ball bearing from a shaft by forcing against the outer race, the bearing should be discarded and replaced.
- **Press fits:** Use suitable machined pushers (The end faces of the pusher should be flat, parallel and burr free) for pressing operations.



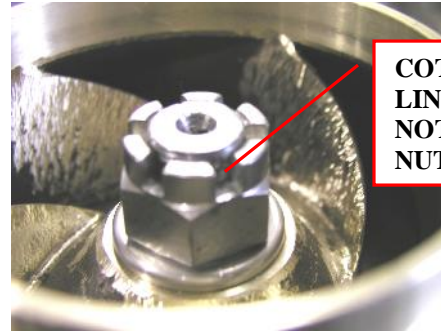
**SUITABLE
PUSHERS**



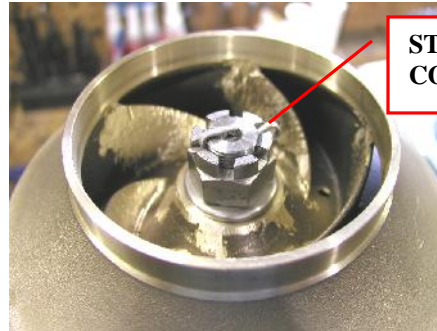
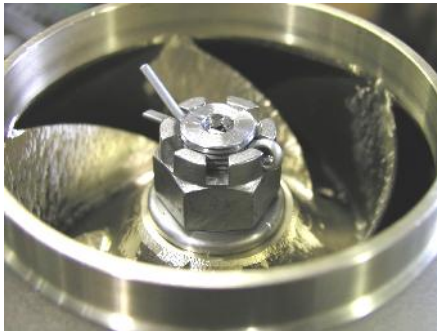
- **Press fits:** When pressing a part into housing (ex. Stuffing box, seal ring, etc.), the part needs to be started perpendicular to the housing.



- **Press fits:** Use a press for forcing press fits whenever possible. If necessary to use a hammer, use one having soft plastic heads. Do not use brass or lead hammers, for the face of the hammer may easily chip or flake, contaminating the assembly, which can cause severe damage to bearings and other precision components.
- **Impeller Nuts:** When installing impeller nuts, DO NOT use an impact wrench. Use of impact wrenches has proven to damage the impeller washers, impellers, and impeller shafts. Proper tightening procedure is to bring it snug tight, and then tighten it to the next available cotter pin hole in shaft and notch in the castle nut. Then install stainless steel cotter pin.



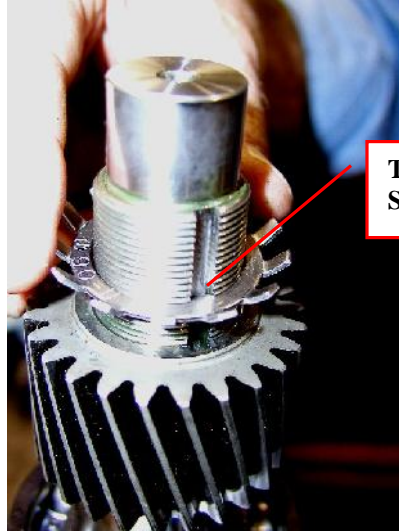
**COTTER PIN HOLE
LINED UP WITH
NOTCH IN CASTLE
NUT**



**STAINLESS STEEL
COTTER PIN**

- Lock Washer/Lock Nut:** Secure shaft so that it doesn't rotate when tightening lock nut. Line up tab on lock washer with keyway slot in shaft and slide washer onto shaft. Screw lock nut onto shaft until snug, then turn until a tab and slot line up. Using a punch, tap tab from lock washer into slot on lock nut.

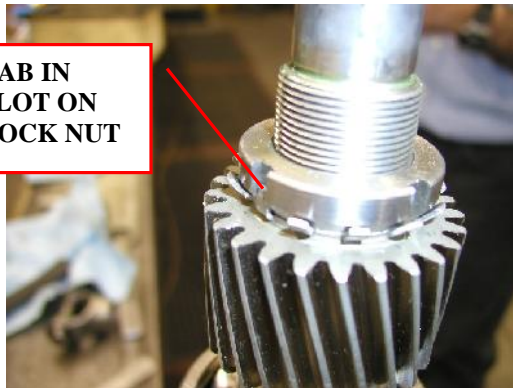
**PROPER
FIXTURE TO
HOLD SHAFT**



**TAB IN KEYWAY
SLOT**



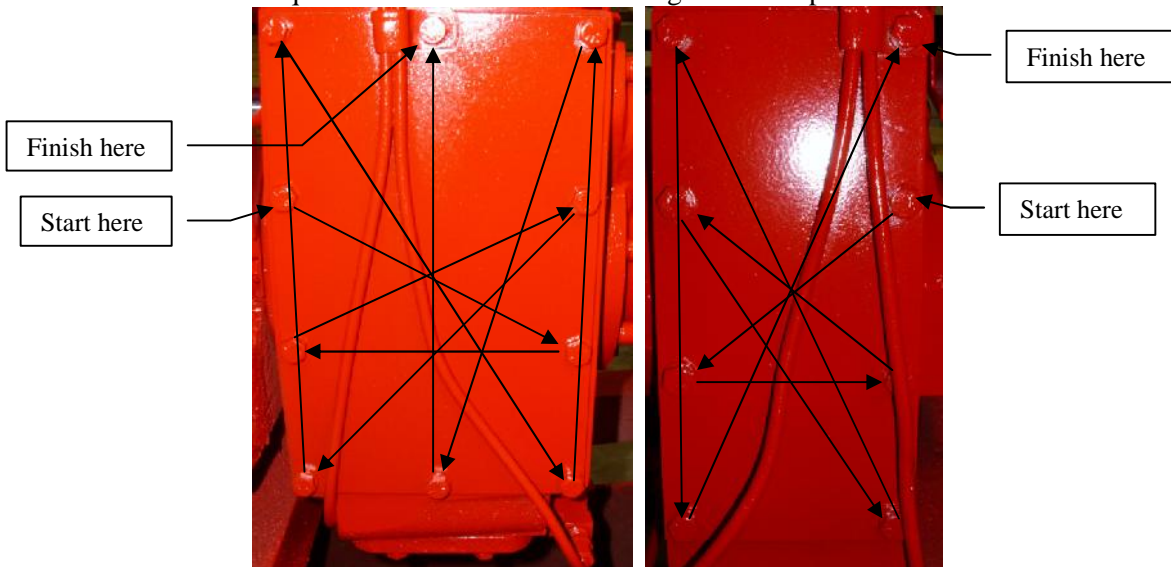
**TAB IN
SLOT ON
LOCK NUT**



- **Loctite/thread locker:** When applying Loctite/thread lockers, only use one small drop per hole, unless explicitly told differently by engineering, a WI, or assembly/repair instruction or assembly supervisor.
- **Loctite/thread locker:** When applying Loctite/thread lockers to lock fasteners going into captive holes (a hole that is only open on one end), apply the thread locker to the threads of the hole.



- **Loctite/thread locker:** When applying Loctite/thread lockers, to lock fasteners that are going to be installed with a pneumatic/power wrench, apply the thread locker to the female threads.
- **Transmission Threads:** Use only lock washers on captive holes. The only exception is if it is an aluminum gear case, then use Loctite 243, or equivalent, and no lock washers.
- **Transmission Threads:** Use lock washers and Loctite 243, or equivalent, if holes are tapped thru.
- **Inspection Plate Fasteners:** Use Loctite 243, or equivalent, on the fasteners that hold the rectangular inspection plate to the side of the transmissions gear case. When installing these fasteners, install all of the fasteners to finger tight, then torque them to a final torque of 72 in.-lbs. in an alternating crossover pattern.



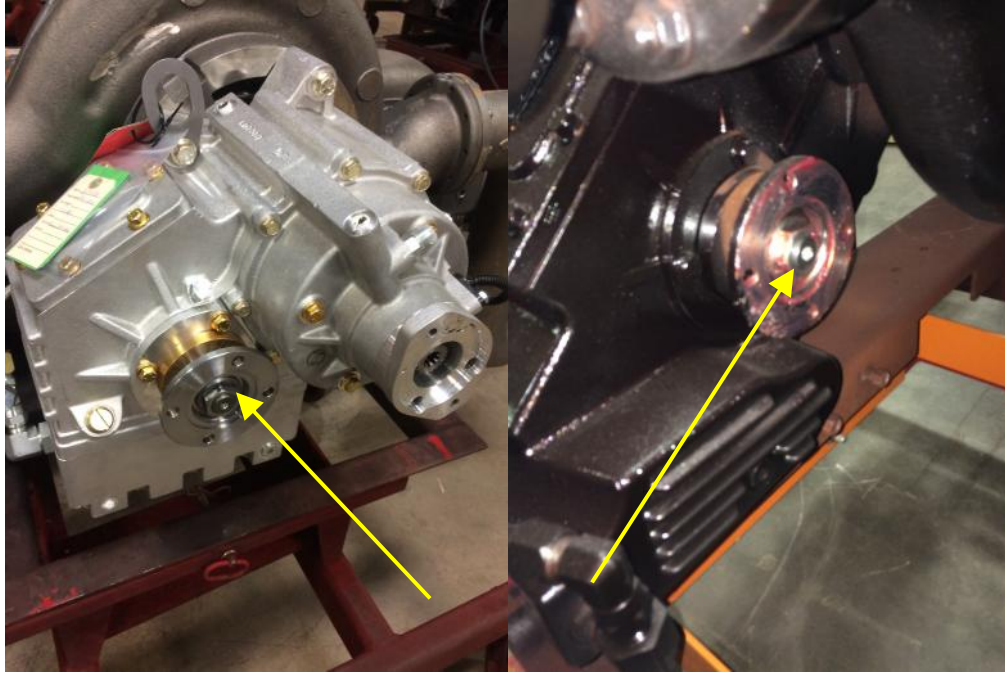
- **Fastener Lock Washers and Aluminum:** Do not use lock washers against aluminum. Use the appropriate thread locker instead.

- **O-rings/Quad rings:** When installing o-rings and quad rings LIGHTLY lube with oil or silicon grease (Dow Corning 111). Be careful not to apply too thick of a film of lubricant when using the silicone grease because over application of the grease can cause the o-ring/quad ring to bridge and leak.



- **Gear Lube:** When filling the gear case with oil, fill with SAE80W/90 gear lube oil to the bottom of the oil level plug on the gear case, or the oil level mark on the dipstick. Maintain the gear case oil level every 25 hours or 3 months, which ever comes first, and change the oil every 50 hours or 6 months.
- **Oil Seal lubrication:** When lubricating oil seals prior to installation, apply a minimal amount of SAE 80/W90 oil on the outside diameter of the seal and the sealing lip on the inside diameter of the seal. Do not use any lubricant other than SAE 80W/90 oil unless a Darley document dated after February 14, 2012 specifically calls it out.

- **Yoke nut installation torque for PUC and PUC-3G pumps:** Torque PUC and PUC-3G yoke nuts to 300-350 ft-lb. After the yoke nut has been torqued down, check to make sure the yoke nut engages the yoke face it bumps up against.



PUC and PUC-3G yoke nuts are tightened to 300-350 lb-ft.

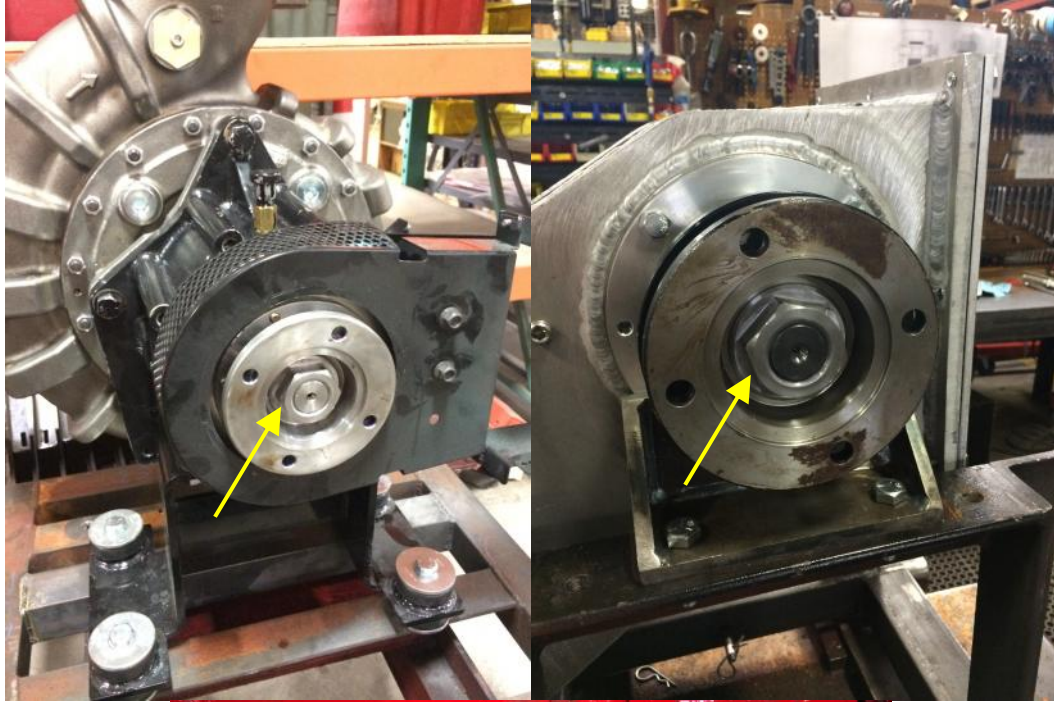
- **Yoke nut torque for 1.75-12 thread, 1.25-12 thread and 7/8-14 thread yoke nuts:** Unless otherwise specified, torque 1.75-12 interference threaded yoke nuts to 150-200 ft-lb. Unless otherwise specified, torque all 1.25-12 thread yoke nuts to 150-200 ft-lb. Unless otherwise specified, torque all 7/8-14 interference threaded yoke nuts to 125 ft-lb. After the yoke nut has been torqued down, check to make sure the yoke nut engages the yoke face it bumps up against.



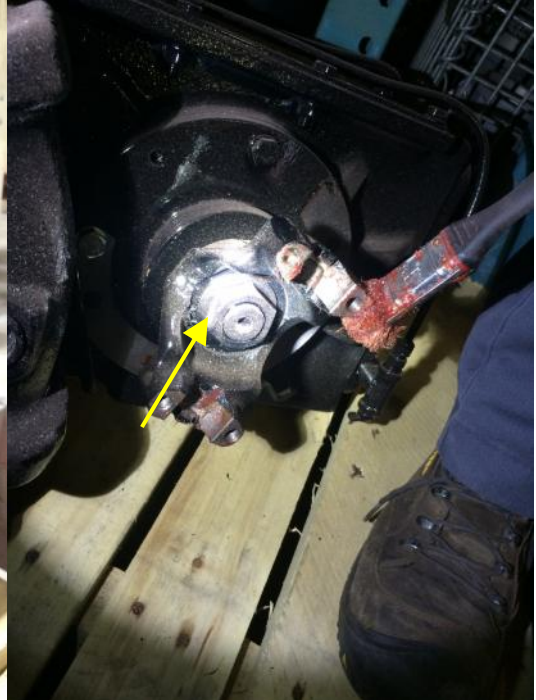
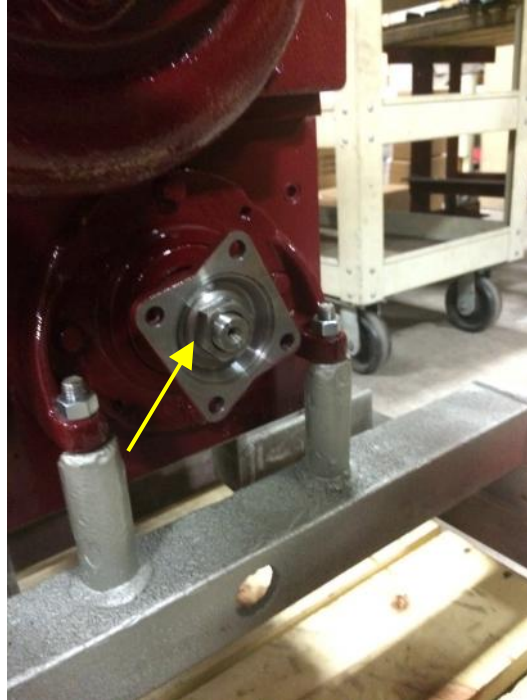
1.75-12 thread yoke nuts are typically used on Midship pump.
1.25-12 thread yoke nuts are typically used on ZSD & ZSP pumps.
7/8-14 thread yoke nuts are used on PTO pumps.



All 1.75-12 interference threaded yoke nuts are torqued to 150-200 ft-lb.



All 1.25-12 threaded yoke nuts are torqued to 150-200 ft-lb.

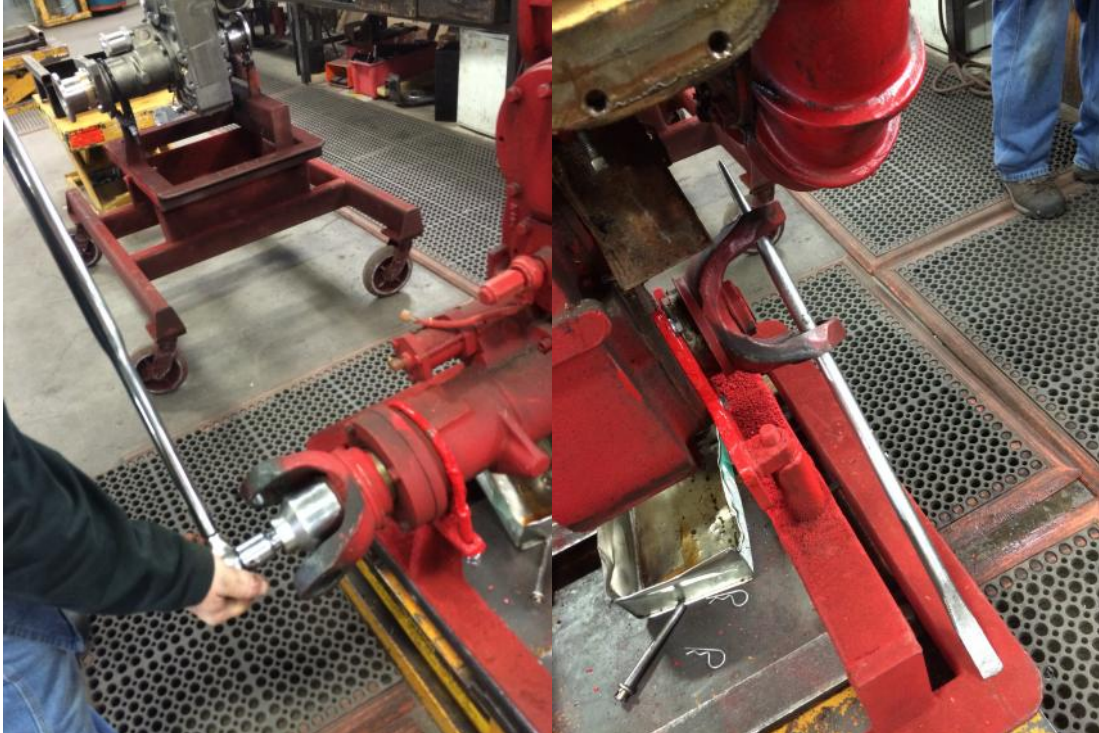


All 7/8-14 interference thread yoke nuts are tightened to 125 ft-lb.

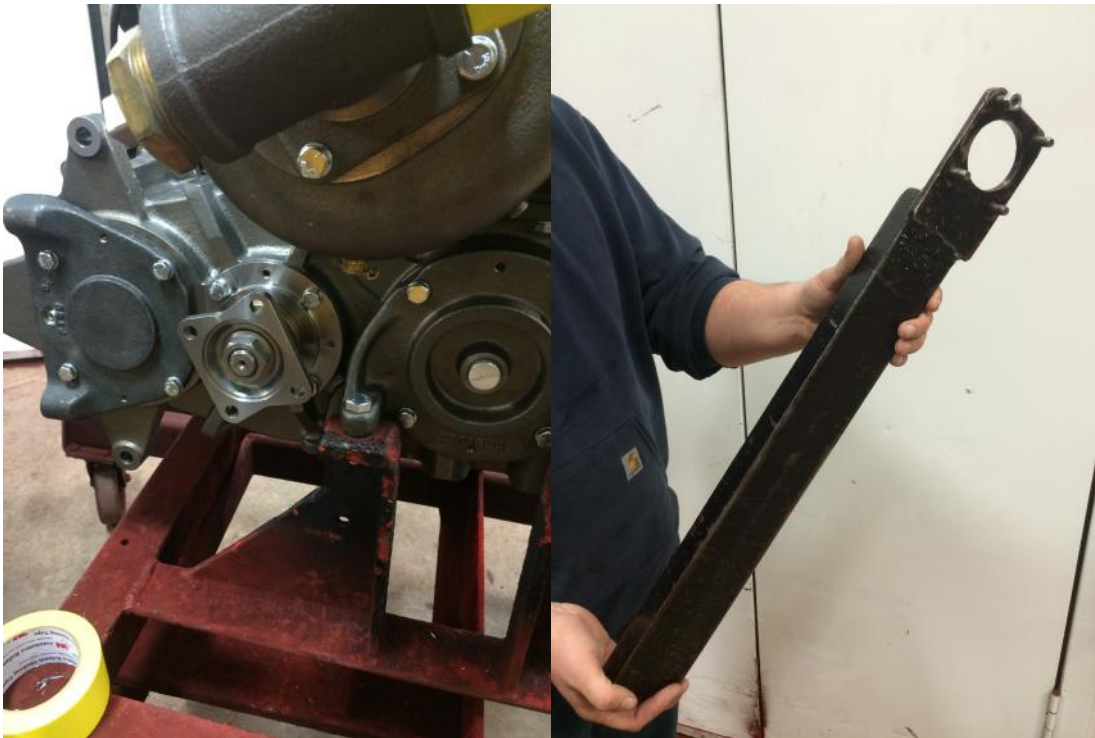


No gaps here

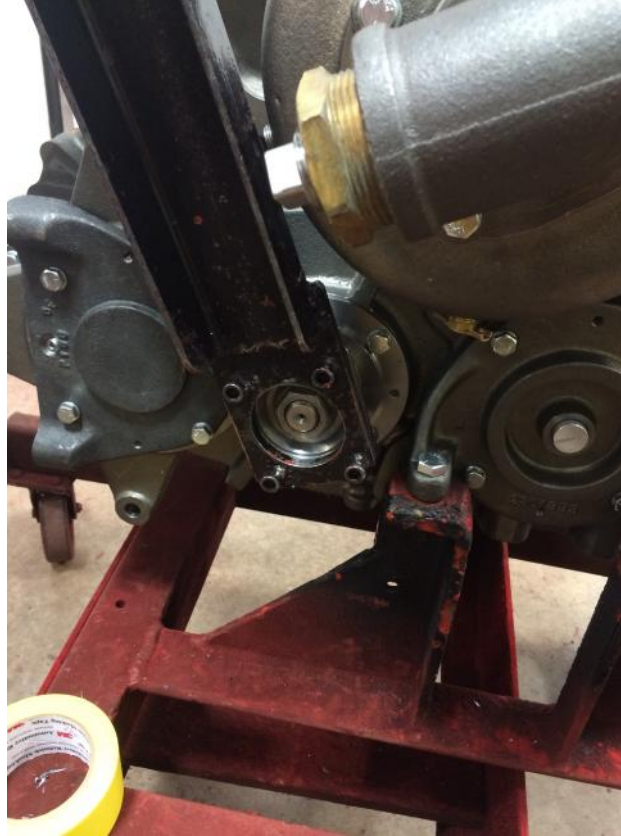
After torquing the yoke nut down, check to make sure there is not a gap between the yoke nut and the yoke.



To help with the yoke nut torquing on midship pumps, shift the transmission into road mode. Put a bar thru the yoke that is not being torqued down to stop the driveline from rotating. Then the driveline will not rotate as the yoke nut is being torqued.



To help with tightening yoke nuts on PTO pumps use the tool shown in the above picture.



Place the tool over the companion flange as shown above. Make sure to finger tighten a nut on one of the tool's fasteners to secure the tool to the yoke.



Now let the tool bump up against a rigid surface and use the torque wrench to tighten the yoke nut as shown above.

Recommended fastener tightening torque unless otherwise specified: The following tables will give recommended tightening torques depending upon the fasteners material and if a Loctite type product was used. Use these recommended tightening torques if you are not confident torqueing a fastener. For fasteners that had a Loctite type product applied to their threads, use the K = .20 (Clean non-plated bolt) recommended tightening torque even if either the nut or bolt was zinc electroplated.

Best practice is to; use an SAE Grade 8 bolt with an SAE Grade 8 nut, use an SAE Grade 5 bolt with and SAE Grade 5 nut, use an SAE Grade 2 bolt with an SAE Grade 2 nut and use the same bolt material as what the nut is made from.

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32 Grade 8	18 to 27 in-lb	654 to 981 lb
#6 – 40 Grade 8	20 to 30 in-lb	730 to 1,095 lb
#8 – 32 Grade 8	33 to 50 in-lb	1,009 to 1,513 lb
#8 – 36 Grade 8	35 to 52 in-lb	1,060 to 1,591 lb
#10 – 24 Grade 8	48 to 72 in-lb	1,262 to 1,893 lb
#10 – 32 Grade 8	55 to 82 in-lb	1,440 to 2,159 lb
¼ - 20 Grade 8	115 to 172 in-lb	2,291 to 3,437 lb
¼ - 28 Grade 8	131 to 196 in-lb	2,619 to 3,928 lb
5/16 – 18 Grade 8	20 to 29 ft-lb	3,775 to 5,662 lb
5/16 – 24 Grade 8	22 to 33 ft-lb	4,181 to 6,271 lb
3/8 – 16 Grade 8	35 to 52 ft-lb	5,579 to 8,369 lb
3/8 – 24 Grade 8	40 to 59 ft-lb	6,324 to 9,485 lb
7/16 – 14 Grade 8	56 to 84 ft-lb	7,654 to 11,481 lb
7/16 – 20 Grade 8	62 to 93 ft-lb	8,548 to 12,821 lb
½ - 13 Grade 8	85 to 128 ft-lb	10,217 to 15,325 lb
½ - 20 Grade 8	96 to 144 ft-lb	11,517 to 17,275 lb
5/8 – 11 Grade 8	170 to 254 ft-lb	16,272 to 24,408 lb
5/8 – 18 Grade 8	192 to 288 ft-lb	18,429 to 27,643 lb
¾ - 10 Grade 8	301 to 452 ft-lb	24,081 to 36,122 lb
¾ - 16 Grade 8	336 to 503 ft-lb	26,853 to 40,280 lb
7/8 – 9 Grade 8	485 to 727 ft-lb	33,245 to 49,867 lb
7/8 – 14 Grade 8	535 to 802 ft-lb	36,682 to 55,023 lb
1 – 8 Grade 8	727 to 1,090 ft-lb	43,614 to 65,421 lb
1 – 12 Grade 8	796 to 1,193 ft-lb	47,739 to 71,608 lb

The above table is for SAE Grade 8 fasteners, K = .20 (Clean non-plated fasteners or Loctited zinc electroplated fasteners)

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32 Grade 8	20 to 30 in-lb	654 to 981 lb
#6 – 40 Grade 8	22 to 33 in-lb	730 to 1,095 lb
#8 – 32 Grade 8	36 to 55 in-lb	1,009 to 1,513 lb
#8 – 36 Grade 8	38 to 57 in-lb	1,060 to 1,591 lb
#10 – 24 Grade 8	53 to 79 in-lb	1,262 to 1,893 lb
#10 – 32 Grade 8	60 to 90 in-lb	1,440 to 2,159 lb
¼ - 20 Grade 8	126 to 189 in-lb	2,291 to 3,437 lb
¼ - 28 Grade 8	144 to 216 in-lb	2,619 to 3,928 lb
5/16 – 18 Grade 8	22 to 32 ft-lb	3,775 to 5,662 lb
5/16 – 24 Grade 8	24 to 36 ft-lb	4,181 to 6,271 lb
3/8 – 16 Grade 8	38 to 58 ft-lb	5,579 to 8,369 lb
3/8 – 24 Grade 8	43 to 65 ft-lb	6,324 to 9,485 lb
7/16 – 14 Grade 8	61 to 92 ft-lb	7,654 to 11,481 lb
7/16 – 20 Grade 8	69 to 103 ft-lb	8,548 to 12,821 lb
½ - 13 Grade 8	94 to 140 ft-lb	10,217 to 15,325 lb
½ - 20 Grade 8	106 to 158 ft-lb	11,517 to 17,275 lb
5/8 – 11 Grade 8	186 to 280 ft-lb	16,272 to 24,408 lb
5/8 – 18 Grade 8	211 to 317 ft-lb	18,429 to 27,643 lb
¾ - 10 Grade 8	331 to 497 ft-lb	24,081 to 36,122 lb
¾ - 16 Grade 8	369 to 554 ft-lb	26,853 to 40,280 lb
7/8 – 9 Grade 8	533 to 800 ft-lb	33,245 to 49,867 lb
7/8 – 14 Grade 8	588 to 883 ft-lb	36,682 to 55,023 lb
1 – 8 Grade 8	800 to 1,199 ft-lb	43,614 to 65,421 lb
1 – 12 Grade 8	875 to 1,313 ft-lb	47,739 to 71,608 lb

The above table is for SAE Grade 8 fasteners, K = .22 (Zinc electroplated bolt or nut)

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32 Grade 5	16 to 24 in-lb	589 to 883 lb
#6 – 40 Grade 5	18 to 27 in-lb	657 to 986 lb
#8 – 32 Grade 5	30 to 45 in-lb	908 to 1,362 lb
#8 – 36 Grade 5	31 to 47 in-lb	954 to 1,432 lb
#10 – 24 Grade 5	43 to 65 in-lb	1,136 to 1,704 lb
#10 – 32 Grade 5	49 to 74 in-lb	1,296 to 1,943 lb
¼ - 20 Grade 5	81 to 122 in-lb	1,623 to 2,434 lb
¼ - 28 Grade 5	93 to 139 in-lb	1,855 to 2,783 lb
5/16 – 18 Grade 5	14 to 21 ft-lb	2,674 to 4,011 lb
5/16 – 24 Grade 5	15 to 23 ft-lb	2,961 to 4,442 lb
3/8 – 16 Grade 5	25 to 37 ft-lb	3,952 to 5,928 lb
3/8 – 24 Grade 5	28 to 42 ft-lb	4,479 to 6,719 lb
7/16 – 14 Grade 5	40 to 59 ft-lb	5,422 to 8,133 lb
7/16 – 20 Grade 5	44 to 66 ft-lb	6,055 to 9,082 lb
½ - 13 Grade 5	60 to 90 ft-lb	7,237 to 10,855 lb
½ - 20 Grade 5	68 to 102 ft-lb	8,158 to 12,236 lb
5/8 – 11 Grade 5	120 to 180 ft-lb	11,526 to 17,289 lb
5/8 – 18 Grade 5	136 to 204 ft-lb	13,054 to 19,581 lb
¾ - 10 Grade 5	213 to 320 ft-lb	17,057 to 25,586 lb
¾ - 16 Grade 5	238 to 357 ft-lb	19,021 to 28,532 lb
7/8 – 9 Grade 5	343 to 515 ft-lb	23,548 to 35,323 lb
7/8 – 14 Grade 5	379 to 568 ft-lb	25,983 to 38,975 lb
1 – 8 Grade 5	515 to 772 ft-lb	30,893 to 46,340 lb
1 – 12 Grade 5	564 to 845 ft-lb	33,815 to 50,723 lb

The above table is for SAE Grade 5 fasteners, K = .20 (Clean non-plated fasteners or Loctited zinc electroplated fasteners)

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32 Grade 5	18 to 27 in-lb	589 to 883 lb
#6 – 40 Grade 5	20 to 30 in-lb	657 to 986 lb
#8 – 32 Grade 5	33 to 49 in-lb	908 to 1,362 lb
#8 – 36 Grade 5	34 to 52 in-lb	954 to 1,432 lb
#10 – 24 Grade 5	47 to 71 in-lb	1,136 to 1,704 lb
#10 – 32 Grade 5	54 to 81 in-lb	1,296 to 1,943 lb
¼ - 20 Grade 5	89 to 134 in-lb	1,623 to 2,434 lb
¼ - 28 Grade 5	102 to 153 in-lb	1,855 to 2,783 lb
5/16 – 18 Grade 5	15 to 23 ft-lb	2,674 to 4,011 lb
5/16 – 24 Grade 5	17 to 25 ft-lb	2,961 to 4,442 lb
3/8 – 16 Grade 5	27 to 41 ft-lb	3,952 to 5,928 lb
3/8 – 24 Grade 5	31 to 46 ft-lb	4,479 to 6,719 lb
7/16 – 14 Grade 5	43 to 65 ft-lb	5,422 to 8,133 lb
7/16 – 20 Grade 5	49 to 73 ft-lb	6,055 to 9,082 lb
½ - 13 Grade 5	66 to 100 ft-lb	7,237 to 10,855 lb
½ - 20 Grade 5	75 to 112 ft-lb	8,158 to 12,236 lb
5/8 – 11 Grade 5	132 to 198 ft-lb	11,526 to 17,289 lb
5/8 – 18 Grade 5	150 to 224 ft-lb	13,054 to 19,581 lb
¾ - 10 Grade 5	235 to 352 ft-lb	17,057 to 25,586 lb
¾ - 16 Grade 5	262 to 392 ft-lb	19,021 to 28,532 lb
7/8 – 9 Grade 5	378 to 567 ft-lb	23,548 to 35,323 lb
7/8 – 14 Grade 5	417 to 625 ft-lb	25,983 to 38,975 lb
1 – 8 Grade 5	566 to 850 ft-lb	30,893 to 46,340 lb
1 – 12 Grade 5	620 to 930 ft-lb	33,815 to 50,723 lb

The above table is for SAE Grade 5 fasteners, K = .22 (Zinc electroplated bolt or nut)

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32 Grade 2	8 to 12 in-lb	300 to 450 lb
#6 – 40 Grade 2	9 to 14 in-lb	335 to 502 lb
#8 – 32 Grade 2	15 to 23 in-lb	462 to 693 lb
#8 – 36 Grade 2	16 to 24 in-lb	486 to 729 lb
#10 – 24 Grade 2	22 to 33 in-lb	579 to 868 lb
#10 – 32 Grade 2	25 to 38 in-lb	660 to 990 lb
¼ - 20 Grade 2	53 to 79 in-lb	1,050 to 1,575 lb
¼ - 28 Grade 2	60 to 90 in-lb	1,200 to 1,801 lb
5/16 – 18 Grade 2	108 to 162 in-lb	1,730 to 2,595 lb
5/16 – 24 Grade 2	120 to 180 in-lb	1,916 to 2,874 lb
3/8 – 16 Grade 2	16 to 24 ft-lb	2,557 to 3,836 lb
3/8 – 24 Grade 2	18 to 27 ft-lb	2,898 to 4,347 lb
7/16 – 14 Grade 2	26 to 38 ft-lb	3,508 to 5,262 lb
7/16 – 20 Grade 2	29 to 43 ft-lb	3,918 to 5,876 lb
½ - 13 Grade 2	39 to 59 ft-lb	4,683 to 7,024 lb
½ - 20 Grade 2	44 to 66 ft-lb	5,278 to 7,918 lb
5/8 – 11 Grade 2	78 to 117 ft-lb	7,458 to 11,187 lb
5/8 – 18 Grade 2	88 to 132 ft-lb	8,447 to 12,670 lb
¾ - 10 Grade 2	138 to 207 ft-lb	11,037 to 16,556 lb
¾ - 16 Grade 2	154 to 231 ft-lb	12,308 to 18,462 lb
7/8 – 9 Grade 2	133 to 200 ft-lb	9,142 to 13,714 lb
7/8 – 14 Grade 2	147 to 221 ft-lb	10,088 to 15,131 lb
1 – 8 Grade 2	200 to 300 ft-lb	11,994 to 17,991 lb
1 – 12 Grade 2	219 to 328 ft-lb	13,128 to 19,692 lb

The above table is for SAE Grade 2 fasteners, K = .20 (Clean non-plated fasteners or Loctited zinc electroplated fasteners)

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32 Grade 2	9 to 14 in-lb	300 to 450 lb
#6 – 40 Grade 2	10 to 15 in-lb	335 to 502 lb
#8 – 32 Grade 2	17 to 25 in-lb	462 to 693 lb
#8 – 36 Grade 2	18 to 26 in-lb	486 to 729 lb
#10 – 24 Grade 2	24 to 36 in-lb	579 to 868 lb
#10 – 32 Grade 2	28 to 41 in-lb	660 to 990 lb
¼ - 20 Grade 2	58 to 87 in-lb	1,050 to 1,575 lb
¼ - 28 Grade 2	66 to 99 in-lb	1,200 to 1,801 lb
5/16 – 18 Grade 2	119 to 178 in-lb	1,730 to 2,595 lb
5/16 – 24 Grade 2	132 to 198 in-lb	1,916 to 2,874 lb
3/8 – 16 Grade 2	18 to 26 ft-lb	2,557 to 3,836 lb
3/8 – 24 Grade 2	20 to 30 ft-lb	2,898 to 4,347 lb
7/16 – 14 Grade 2	28 to 42 ft-lb	3,508 to 5,262 lb
7/16 – 20 Grade 2	31 to 47 ft-lb	3,918 to 5,876 lb
½ - 13 Grade 2	43 to 64 ft-lb	4,683 to 7,024 lb
½ - 20 Grade 2	48 to 73 ft-lb	5,278 to 7,918 lb
5/8 – 11 Grade 2	85 to 128 ft-lb	7,458 to 11,187 lb
5/8 – 18 Grade 2	97 to 145 ft-lb	8,447 to 12,670 lb
¾ - 10 Grade 2	152 to 228 ft-lb	11,037 to 16,556 lb
¾ - 16 Grade 2	169 to 254 ft-lb	12,308 to 18,462 lb
7/8 – 9 Grade 2	147 to 220 ft-lb	9,142 to 13,714 lb
7/8 – 14 Grade 2	162 to 243 ft-lb	10,088 to 15,131 lb
1 – 8 Grade 2	220 to 330 ft-lb	11,994 to 17,991 lb
1 – 12 Grade 2	241 to 361 ft-lb	13,128 to 19,692 lb

The above table is for SAE Grade 2 fasteners, K = .22 (Zinc electroplated nut or bolt)

Fastener Size	Recommended tightening torque	Clamp load
#6 – 32	3 to 5 in-lb	125 to 188 lb
#6 – 40	4 to 6 in-lb	140 to 210 lb
#8 – 32	6 to 10 in-lb	193 to 290 lb
#8 – 36	7 to 10 in-lb	203 to 305 lb
#10 – 24	9 to 14 in-lb	242 to 363 lb
#10 – 32	10 to 16 in-lb	276 to 414 lb
¼ - 20	22 to 33 in-lb	439 to 659 lb
¼ - 28	25 to 38 in-lb	502 to 753 lb
5/16 – 18	45 to 68 in-lb	724 to 1,085 lb
5/16 – 24	50 to 75 in-lb	801 to 1,202 lb
3/8 – 16	80 to 120 in-lb	1,069 to 1,604 lb
3/8 – 24	91 to 136 in-lb	1,212 to 1,818 lb
7/16 – 14	128 to 193 in-lb	1,467 to 2,201 lb
7/16 – 20	143 to 215 in-lb	1,638 to 2,457 lb
½ - 13	16 to 24 ft-lb	1,958 to 2,937 lb
½ - 20	18 to 28 ft-lb	2,207 to 3,311 lb
5/8 – 11	32 to 49 ft-lb	3,119 to 4,678 lb
5/8 – 18	37 to 55 ft-lb	3,532 to 5,298 lb
¾ - 10	58 to 87 ft-lb	4,616 to 6,923 lb
¾ - 16	64 to 97 ft-lb	5,147 to 7,720 lb
7/8 – 9	93 to 139 ft-lb	6,372 to 9,558 lb
7/8 – 14	103 to 154 ft-lb	7,031 to 10,546 lb
1 – 8	139 to 209 ft-lb	8,359 to 12,539 lb
1 – 12	152 to 229 ft-lb	9,150 to 13,725 lb

The above table is for Stainless Steel, Bronze or Aluminum fasteners. By fasteners we are implying nuts or bolts – not stationary components in the clamped joint. K = .20 (Clean non-plated fasteners with or without a Loctite type product)

Socket set screw size	Minimum tightening torque for alloy steel socket set screws	Minimum tightening torque for stainless socket set screws
#6	10 in-lb	7 in-lb
#8	19 in-lb	16 in-lb
#10	34 in-lb	26 in-lb
¼	78 in-lb	70 in-lb
5/16	156 in-lb	130 in-lb
3/8	23 ft-lb	230 in-lb
7/16	36 ft-lb	28 ft-lb
1/2	51 ft-lb	42 ft-lb
5/8	110 ft-lb	82 ft-lb
3/4	179 ft-lb	142 ft-lb
7/8	428 ft-lb	333 ft-lb
1	584 ft-lb	467 ft-lb

The above table is the recommended minimum tightening torque for alloy steel and stainless socket set screws. Please note the recommended tightening torque is the same for both fine threaded and coarse threaded set screws

For reference, Recommended tightening torque is found by the following equation;

$$T = KDP$$

T = Tightening torque in units of inch-pound.

K = Nut factor and it is unit less.

D = Nominal bolt diameter in units of inch.

P = Clamp load in units of pounds.

Nut factor = K = .20 or .22 in these tables. K = .20 for clean non-plated bolts. K = .25 for zinc electroplated bolts. See IFI handbook 6th edition on page M-64 for more details.

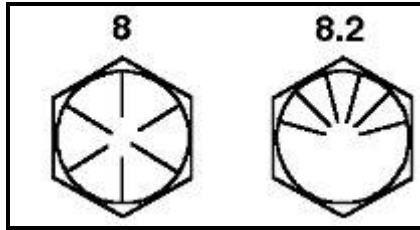
Our recommended tightening torques is intended to maintain a clamp load of 60% to 90% of the bolt's proof load. See Mechanical Engineering Design ISBN 0-07-056888-X page 382 for more details.

We assumed a Grade 8 proof load of 120,000 psi for all fasteners sizes.

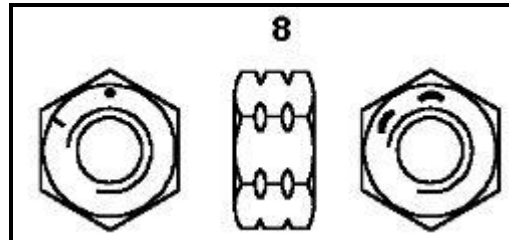
We assumed a Grade 5 proof load of 85,000 psi for fasteners 1/4" in bolt diameter up to 1" in bolt diameter. We assumed a Grade 5 proof load of 108,000 psi for fasteners #6 up to #10 in bolt diameter. We assumed a Grade 2 proof load of 33,000 psi for fasteners larger than 3/4" in bolt diameter up to 1-1/2" in bolt diameter. We assumed a Grade 2 proof load of 55,000 psi for fasteners #6 in bolt diameter up to 5/8" in bolt diameter.

We assumed a proof load of 23,000 psi for all Stainless Steel, Bronze and Aluminum material fasteners. Sand cast 356.0-T6 aluminum has a yield strength of 24,000 psi listed in the ASM Specialty Handbook Aluminum and Aluminum Alloys on page 720.

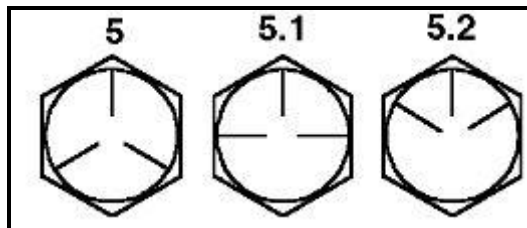
Fastener Size	Nominal bolt diameter (in)	Tensile stress area (square inch)	Stainless, Brass, Bronze or Aluminum proof load (lb)	SAE Grade 2 proof load (lb)	SAE Grade 5 proof load (lb)	SAE Grade 8 proof load (lb)
#6 – 32	.1380	.00909	209	500	981	1,090
#6 – 40	.1380	.01015	233	558	1,095	1,217
#8 – 32	.1640	.0140	322	770	1,513	1,681
#8 – 36	.1640	.01474	339	810	1,591	1,767
#10 – 24	.1900	.0175	403	964	1,893	2,104
#10 – 32	.1900	.0200	460	1,100	2,159	2,399
1/4 - 20	.250	.0318	732	1,750	2,705	3,819
1/4 - 28	.250	.0364	837	2,001	3,092	4,365
5/16 – 18	.3125	.0524	1,206	2,884	4,457	6,292
5/16 – 24	.3125	.0580	1,336	3,194	4,936	6,968
3/8 – 16	.375	.0775	1,782	4,262	6,587	9,299
3/8 – 24	.375	.0878	2,020	4,831	7,465	10,539
7/16 – 14	.4375	.1063	2,445	5,847	9,036	12,757
7/16 – 20	.4375	.1187	2,730	6,529	10,091	14,246
1/2 - 13	.500	.1419	3,264	7,804	12,061	17,028
1/2 - 20	.500	.1599	3,679	8,797	13,596	19,194
5/8 – 11	.625	.226	5,198	12,430	19,210	27,120
5/8 – 18	.625	.256	5,887	14,078	21,759	30,715
3/4 - 10	.750	.334	7,693	18,395	28,429	40,135
3/4 - 16	.750	.373	8,578	20,513	31,702	44,755
7/8 – 9	.875	.462	10,620	15,237	39,247	55,408
7/8 – 14	.875	.509	11,718	16,813	43,305	61,137
1 – 8	1.000	.606	13,932	19,990	51,488	72,689
1 – 12	1.000	.663	15,250	21,880	56,359	79,565



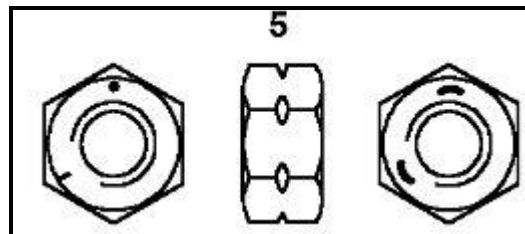
The above image shows how SAE Grade 8 hex head bolts can be identified.



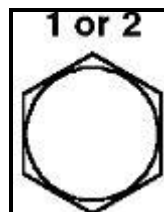
The above image shows how SAE Grade 8 hex nuts can be identified.



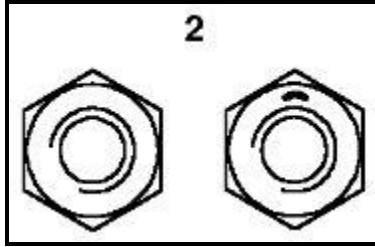
The above image shows how SAE Grade 5 hex head bolts can be identified.



The above image shows how SAE Grade 5 hex nuts can be identified.



The above image shows how SAE Grade 2 hex head bolts can be identified.



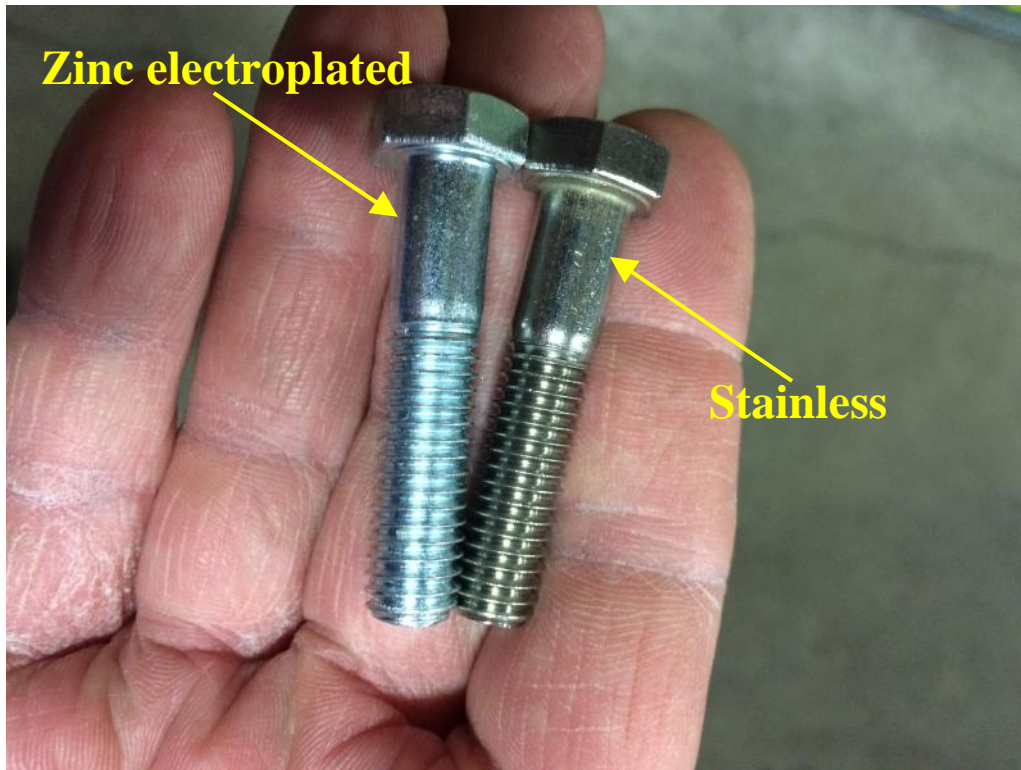
The above image shows how SAE Grade 2 hex nuts can be identified.



The above images show different types of zinc electroplated fasteners.



The above images show different types of clean non-plated fasteners.



**The bolt on the left is zinc electroplated.
The bolt on the right is stainless steel.**



The above image is a brass machine screw and brass hex nut.



All alloy steel socket head cap screws have an 180,000 psi tensile strength for 1/2" and smaller bolts and 170,000 psi tensile strength for 5/8" and larger bolts. Use the SAE Grade 8 recommended tightening torque tables for socket head cap screws.



All alloy steel socket flat countersunk head cap screws have a 150,000 psi minimum tensile strength. Use the SAE Grade 8 recommended tightening torque tables for alloy steel socket flat countersunk head cap screws.



All alloy steel socket button head cap screws have a 137,000 psi minimum tensile strength. Use the SAE Grade 5 recommended tightening torque tables for alloy steel socket button head cap screws.



The fasteners on the left are alloy steel socket set screws. The fasteners on the right are stainless socket set screws.

If further information is needed, call **Darley** at
Chippewa Falls, WI. - 800-634-7812 or 715-726-2650

Prepared by: DLH
Approved by: Engineering
Revised by: WAH

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