

HOW TO USE THIS MANUAL

This manual provides detailed instructions on disassembly and assembly of Type AFX right angle drives. Use the table of contents below to locate required information.

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INTRODUCTION

The following instructions apply to standard Type AFX right angle drives with vertical output shafts. Drawings are representative of this series of right angle gear drives and may not agree in exact detail with all sizes. When ordering parts or requesting information, specify M.O. number, drive size, model number, rpm, ratio and date stamped on the drive nameplate. Consult Factory BEFORE changing speed or ratio. Operate only at speeds shown on nameplate.

RATIO CHANGE—Ratio change is accomplished by changing the helical gear ratio in the high speed end of the drive without disturbing the bevel gearset. Reduction changes (i.e., double to triple reduction) require new high speed heads on sizes 284 through 388 and new helical gearing on all sizes.

CAUTION: Consult applicable local and national safety codes for proper guarding of rotating members.

Lock out power source and remove external loads from drive before servicing drive or accessories.

RECOMMENDATIONS

When replacing a pinion, replace the entire assembly (pinion, shaft, bearings, spacers, etc.) and the mating gear. Bevel pinion and bevel gear must be replaced as a set if either element requires replacement. Also replace oil seals and shim gaskets when reassembling drives.

LIFTING INSTRUCTIONS

Disconnect all attached equipment and drain oil. Sling drive from lifting lugs (3) and lift from foundation.

REQUIRED EQUIPMENT

In addition to standard mechanic's tools, the following equipment is required: hoist, sling, arbor press, wheel puller, torque wrench, spanner wrench, special eyenut (for lifting bevel pinion assembly), feeler gauges, dial indicator with stand and inside & outside micrometers.

GENERAL INSTRUCTIONS

1. **PRE-DISASSEMBLY** — To prevent dirt from falling into the drive, clean all external surfaces of reducer before disassembly. Record mounting dimensions of couplings and accessories for reference when reassembling.
2. **OIL SEALS** — Replacement is recommended. However, if seals are not to be replaced, refer to steps 6A and 6G before starting disassembly.
3. **SHIMS AND SHIM GASKETS** — During disassembly, wire or tie all shims or shim gaskets to their respective bearing cages, seal cages or end covers for reference when reassembling.
4. **CAUTION:** A number of helical pinions on high speed shafts are keyless for triple and quadruple reduction drives. The high interference fit makes these assemblies "solid-on-shaft" and, for all practical purposes, inseparable. If there is no evidence of a key or keyway, replace the assembly. See Table 7 for a listing of these assemblies.
5. **REMOVAL OF TAPER BORE HELICAL GEARS** — see Step 8.
6. **OIL SEAL REPLACEMENT ONLY** — Figures 1A, 1B and 1C. The high speed shaft and lower low speed shaft seal cages must be removed for oil seal replacement. The upper low speed seal shaft may be replaced without disturbing the seal cage. If the drive is to be totally disassembled, start with Step 7. If only the seals are to be replaced, proceed as follows:
 - A. Clean the shaft extensions, but DO NOT ALLOW abrasive materials to mar the shaft surface polished by the seal.
 - B. Remove seal cages where required, save the shim gaskets for reference when reassembling.
 - C. Drive out the seals and remove sealing compound and gasket material from seal cage. Replace seal cage if it has been damaged or bent. On upper low speed shaft seal cages, punch or drill holes in the seal case, install sheet metal screws and pry out old seal. Punch method is preferred. **CAUTION:** Seal cage must be removed from drive to remove seal if seal is driven into bearing cavity.
 1. Drill Method—Wrap several turns of tape around the drill approximately .250" from the drill point to prevent the drill from entering too deeply into the housing and damaging the bearing. Grease or magnetize the drill to help retain the chips. Drill two .125" diameter holes in the seal cage 180° apart. Control the angle of the drill as illustrated in Figure 1A, to prevent damage to the shaft.

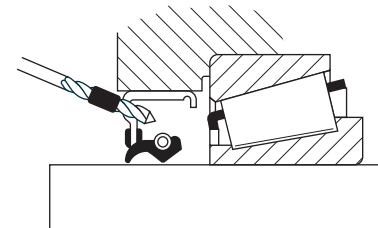


Figure 1A Drill Method

2. Insert two #10-.750" sheet metal screws into the seal leaving .500" of the screw protruding above the seal face. DO NOT drive the screw more than .250" beyond seal face or bearing damage may occur. Use a claw type pry bar under the screw head as shown in Figure 1B and lift the seal out. Remove all chips. Use a magnet to remove the chips that fall into the bore. Remove Permatex from the seal cage bore.

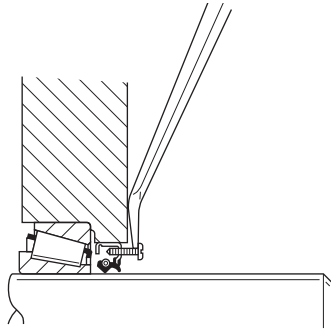


Figure 1B

- D. Coat outside diameter of new seal with Permatex #3 or equivalent sealant.
- E. Figure 1C—Position seal squarely in seal cage with the garter spring towards the bearing. Place a square ended cylindrical tool against the seal and press or lightly tap the tool (not the seal) until the seal is seated in the seal cage.

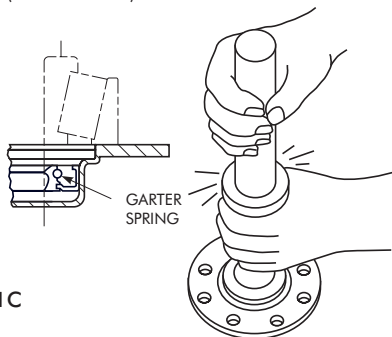


Figure 1C

- F. Clean face of drive. Remove old gasket material. For shafts with ball bearings, replace shim gasket with a new one of the same thickness. For shafts with tapered roller bearings, adjust preload or axial float as required. Replace shim gaskets with new ones of the same total thickness and add additional .007" and .009" shim gaskets to ensure axial float on initial check. See Table 1 for shim gaskets available from the Factory. Use only one .015" shim-gasket in each shim pack, place that shim-gasket against the seal cage when it is a stamping or against the housing when it is a casting.

TABLE 1 — Shim-Gasket Compressibility

Thickness Inches	New	.007	.009	.015	.031
	Compressed	.006	.008	.013	.028

- G. **CAUTION:** Protect seal lips from the sharp edges of the keyway by wrapping thin strong paper around the shaft and coating the paper and seal lips with grease before sliding the seal on or off the shaft. Do not expand the seal lips more than .03" diameter.
- H. High speed seal cages on all Size 273 drives and Sizes 284 through 357 double reduction drives are unregistered and must be centered on the shaft. To center these cages, tighten fasteners finger tight, check shaft to cage bore clearance at 90° intervals with a feeler cage and lightly tap cage to center within .004".
- J. Install seal cage and fasteners with lock washers. Center unregistered cages as indicated in Step 6H. Cross tighten fasteners to torque value specified in Table 2.
- K. For shafts with tapered roller bearings, check and adjust bearing preload or axial float after new shim gaskets have been installed as explained in Step 6F. Refer to Table 3 for bearing preload and axial float limits. To obtain accurate

readings, turn the drive so that the shaft being checked is in the vertical position. Attach eye bolts to the low speed shaft or "C" clamp to the high speed shaft extension to serve as a push/pull device and measure & adjust preload or axial float as instructed in Steps 22, 26, 27 and 31.

TABLE 2 — Fastener Tightening Torque ★

Fastener Location	Fastener Size					
	.312-18	.375-16	.500-13	.625-11	.750-10	.875-9
	Tightening Torque - lb-in.					
H.S. Seal Cages Int. Shaft End Covers H.S. Head Thrust Plate Internal (Hex Head)	145	255	640	1280	...	...
Oil Dam Mounting (Nylon Pellet)	...	150	...	...	...	...
H.S. Head Thrust Plate Internal (Slotted Head Machine Screw)	...	95	...	...	...	...
L.S. Pinion Bearing Cage (Coated Fasteners) L.S. Shaft Seal Cages and End Covers H.S. Bearing Plate Mounting Pedestal/Foundation Plate Mounting	185	330	825	1640	2940	4560

★ Torque values are for shop dry – non lubricated threads.

TABLE 3 — Bearing Adjustment – Inches †

(Part reference number and drive reduction from Fig. 2)

DRIVE SIZE	Total Shaft Axial Float - Inches							Preload Inches
	Ref. #1 Double	Ref. #1 Triple	Ref. #1 Quad.	Ref. #3 Triple	Ref. #2 Quad.	Ref. #3 Quad.	Ref. #4 All Red.	Ref. #5 All Red.
273	†	.011 Min.	...	.011 Min.	.011 Min.	.011 Min.	.001-.003	.001-.004
284	†	†	†	.011 Min.	.011 Min.	.011 Min.	.001-.003	.001-.004
305	†	†	†	.011 Min.	†	.011 Min.	.001-.003	.001-.004
326	.004-.006	†	†	.011 Min.	.011 Min.	.011 Min.	.001-.003	.001-.004
357	.005-.006	†	†	.004-.006	.005-.008	.004-.006	.001-.003	.001-.004
388	.005-.008	.005-.008	.005-.008	.004-.006	.005-.008	.004-.006	.001-.003	.001-.004

† Ball Bearings above heavy line; tapered roller bearings below heavy line. If the minimum ball bearing float is less than that shown in table, add one gasket to increase shaft axial float.

† One bearing takes all the thrust; the other bearing floats axially.

HIGH SPEED END REMOVAL — Figure 2

Start with the high speed end of the drive and work thru to the low speed end. The low speed (bevel gear) shaft may be removed from the drive for service without disturbing the remainder of the drive.

Figure 2 SHAFT ASSEMBLIES

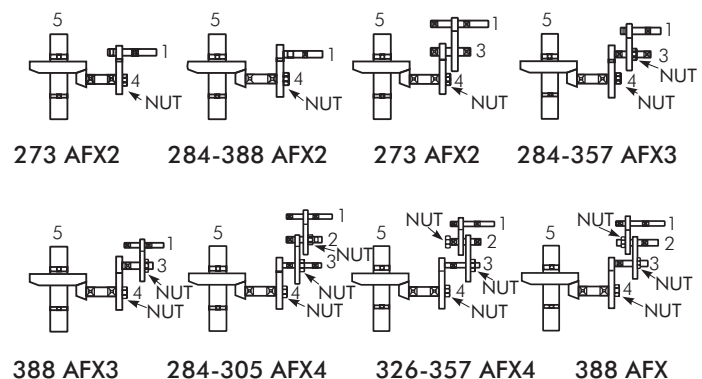
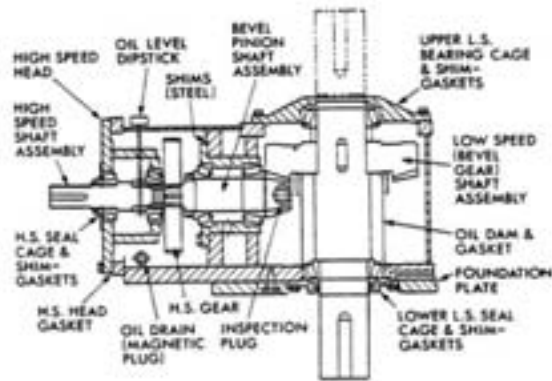
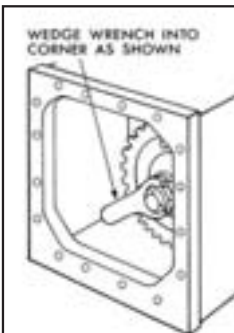
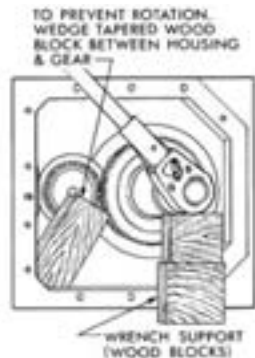
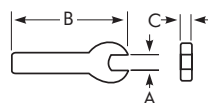


Figure 2A Typical AFX2

7. Size 273.

- A. Stand drive on end (properly supported) with high speed shaft extension up. Remove high speed seal cage and high speed head (bearing plate) fasteners.
- B. Protect the seal lips per Steps 6A and 6G if seal is to be reused. Remove the seal cage (save the shim gaskets). On double reduction drive, remove the retaining ring from the outer high speed bearing.
- C. Install two eye bolts into the two lower tapped holes provided in the bearing plate for the seal cage and then, while lifting, tap the edge of the high speed bearing plate with a brass hammer to break it loose from the housing and the high speed pinion assembly.

**Figure 3A LOCKNUT REMOVAL
SIZES 284-388**


Cut a standard wrench to the dimensions shown.



Dimension	Inches
A	1.625
B	7.750
C	.750

**Figure 3B LOCKNUT REMOVAL
SIZE 273**

- D. Secure the taper-bored gear locknut with a “short wrench”, refer to Figure 3B. Loosely replace the bearing plate to provide stability to the outer high speed bearings. Wrap shim stock or protective material around the high speed shaft and turn the shaft with a spanner wrench to back off the locknut to the end of the shaft.

IMPORTANT: TO LOOSEN THE LOCKNUT — On double reduction drives, turn the high speed shaft counterclockwise (when facing the outer end of the high speed shaft); on triple reduction drives, turn the high speed shaft clockwise.

- E. Remove bearing plate and pull the high speed shaft and intermediate shaft assemblies out of the inner housing wall, do not damage gear teeth. On some drive ratios, it is necessary to remove the taper-bored gear (Step 7F) before the other shaft assemblies can be removed.
- F. Remove taper-bore gear from bevel pinion shaft (Figure 4A or 4B). Leave locknut loosely threaded on shaft to prevent gear from “popping” out of drive. If gear is to be reused, protect the gear teeth with copper or brass sheet stock. Using wedges or pry bar, tap wedges behind gear or pry gear away from inner housing wall. While holding pressure on gear, lightly tap locknut on shaft end to loosen gear on shaft. Remove nut, other shaft assemblies (Step 7E) and taper bore gear, work high speed shaft assembly around high speed bearing oil distributor to remove.

8. Sizes 284 thru 388.

- A. Stand drive on end (properly supported) with high speed shaft extension up. Remove high speed head mounting fasteners and threaded dowels (threaded dowels used in triple and quadruple reduction drives). Install eye bolts in threaded holes of head, sling and lift head out of drive, tap edge of head to break gasketed joint while lifting. On double reduction drives, the head dowel disengages while lifting. On triple and quadruple reduction drives, the head must be joggled for gear clearance while lifting.
- B. Loosen taper bore gear locknut (on bevel pinion shaft). Use 3/4 drive impact wrench (preferred) or socket wrench. The socket wrench method requires wood blocks for locking the gear and wrench head support (Figure 3A) and housing repositioned to accept wrench loads without moving. Refer to Table 4 for locknut data.

**TABLE 4 — Bevel Pinion Shaft Gear Locknut
Data (Shaft #4 - Fig. 2)**

DRIVE SIZE	Thread Size	Wrench Size
273	1.125-12UNF	1.625
284	1.250-12UNF	1.812
305	1.500-12UNF	2.194
326	1.750-12UNF	2.750
357	1.750-12UNF	2.750
388	1.750-12UNF	2.750

- C. Remove taper bore gear from bevel pinion shaft: Leave gear locknut loose on shaft to prevent gear from “popping” out of drive upon fit release. Use gear removal methods as shown in Figures 4A thru 4D (wedge or pry bar method on sizes 284 thru 326 and wheel puller method on Sizes 357 thru 388). If required, apply heat to gear hub (with removal force applied) to release gear from shaft. Do not reuse gear if gear teeth were heated over 275°F. Remove locknut and gear.

HIGH SPEED HEAD DISASSEMBLY

Sizes 284 thru 388 — Refer to Figure 2. Shafts 1, 2 and 3 are supported in the high speed head.

9. DOUBLE REDUCTION DRIVES

A. Remove high speed seal cage.

Figure 4 TAPER-BORED GEAR REMOVAL

LEAVE LOCKNUT ON SHAFT AS SHOWN TO PREVENT GEAR FROM POPPING OFF WHEN FREED

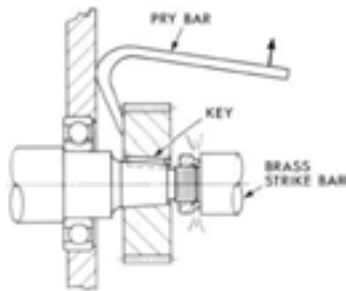


Figure 4B

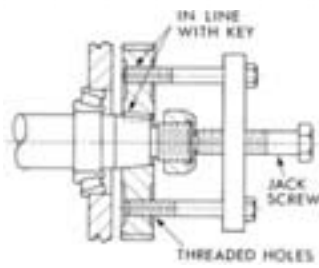


Figure 4C

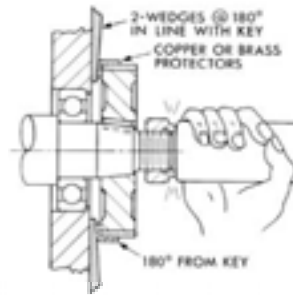


Figure 4A

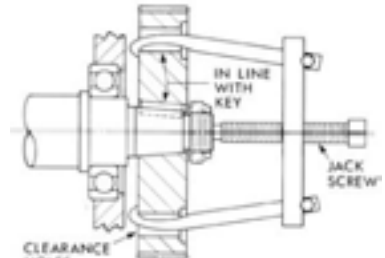


Figure 4D

B. **Sizes 284 and 305** — Remove bearing retaining rings. Remove high speed shaft assembly #1 from high speed end toward pinion.

Sizes 326 thru 388 — Remove the high speed pinion assembly through the bearing bores toward the shaft extension end. EXCEPTIONS: Heat the following high speed pinions to the temperatures shown. Then, press or pull off the pinion and withdraw the shaft and bearing assembly. Remove inner bearing cup. Discard pinion if teeth are heated over 275°F.

#1 PINION MAXIMUM TEMPERATURES

Size 326 — Ratios 5.06 and 6.20
 Size 357 — Ratios 5.06 thru 7.59
 Size 388 — Ratios 5.06 thru 9.30 } 275°F (135°C)

10. TRIPLE AND QUADRUPLE REDUCTION DRIVE.

- A. Start with intermediate shaft assembly #3 and work back toward the high speed shaft.
- B. Remove intermediate shaft end cover or covers.
- C. Hold the locknut on the intermediate shaft with a wrench and turn the high speed shaft extension with a spanner wrench to remove locknut.
- D. Remove intermediate shaft inner bearing retaining ring if so equipped. On Sizes 357 and 388, remove the inner intermediate thrust plate.
- E. Place two spacer blocks between the gear face and the wall of the high speed head. Place a brass bar at the shaft end nearest the locknut and strike the bar a sharp blow with a hammer to free the gear.
- F. Remove the shaft assembly and the gear from the high speed head.
- G. Remove the high speed seal cage and high speed shaft assembly.
- H. If the inner bearing or pinion must be removed from the intermediate shaft (#3), first remove the shaft from the high speed head. For several pinion ratios, the pinion may more

easily be removed from the shaft by heating the pinion to a maximum of 275°F(135°C).

J. A number of high speed shaft assemblies have keyless bored pinions and non-removable bearings, refer to Step 13 and Table 7.

LOW SPEED END DISASSEMBLY

11. BEVEL PINION SHAFT— Figure 5.

A. Remove bevel pinion bearing cage fasteners. Attach special eye nut to shaft end (refer to Table 4 for thread sizes), sling and lift shaft assembly out of drive. Save steel shims for reference at reassembly.

TABLE 5 — Locknut Tightening Torque † – lb-in.

DRIVE SIZE	All Ref. #4	Ref. #3 Triple Ref. #3 Quadruple	Ref. #2 Quadruple
273	1800	...	...
284	1500+30° (2700)	1150	300
305	1500+45° (3540)	1600	350
326	1500+60° (2400)	2400	500
357	1500+60° (6340)	3100	700
388	1500+75° (9540)	4600	1300

† The complete locknut must be coated with SAE or heavier mineral oil.

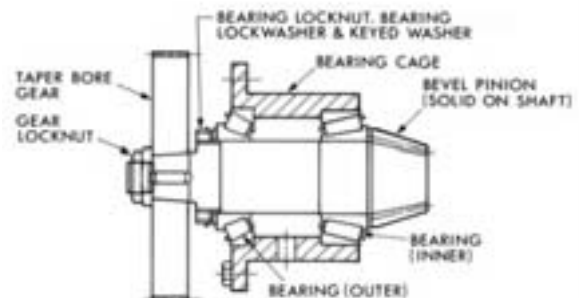


Figure 5 BEVEL PINION ASSEMBLY

TABLE 6 — Gear Nut Tightening Torque at High Speed Shaft – lb-in

AGMA Ratio	DRIVE SIZE					
	273	284	305	326	357	388
High Speed Gear on Ref. #3 Shaft Assembly, Figure 2						
38.44	...	625	870	1070	1660	2050
47.08	...	520	700	880	1385	2050
57.66	...	415	580	720	1140	1385
70.62	...	345	460	585	935	1385
86.50	...	275	380	475	935	1125
105.9	...	230	325	385	935	1125
129.7	...	185	255	385	615	735
158.9	...	155	220	385	500	735
194.6	...	155	220	385	500	735
High Speed Gear on Ref. #2 Shaft Assembly, Figure 2						
238.4	...	165	190	220	310	470
291.9	...	135	155	180	310	375
357.5	...	90	100	145	255	310
437.9	...	90	100	145	205	265
536.3	...	50	100	145	205	265
656.8	...	50	60	80	170	205
804.5	...	50	60	80	115	205
985.3	...	50	60	80	115	205
1207	...	50	60	80	115	205
Intermediate Gear on Ref. #3 Shaft Assembly, Figure 2						
238.4	...	100	140	175	225	405
291.9	...	80	110	140	225	325
357.5	...	55	75	115	185	265
437.9	...	55	75	115	150	225
536.3	...	30	75	115	150	225
656.8	...	30	40	65	120	180
804.5	...	30	40	65	85	180
985.3	...	30	40	65	85	115
1207	...	30	40	65	85	115
High Speed Gear on Ref. #4 Shaft Assembly, Figure 2						
5.06	1470	2235	2880	4430	5215	7795
6.20	1190	1785	2340	3630	4350	6160
7.59	965	1450	1915	2990	3475	5175
9.30	805	1205	1580	2435	2845	4290
11.39	660	990	1300	2055	2290	3415
13.95	540	815	1065	1670	1885	2820
17.09	440	650	830	1315	1570	2285
20.93	355	520	700	1090	1280	1830
25.63	290	430	575	905	1025	1565
31.39	240	350	465	740	860	1220
Intermediate Gear on Ref. #4 Shaft Assembly, Figure 2						
38.44	185	285	380	590	685	1020
47.08	150	235	305	485	570	815
57.66	125	190	255	395	470	690
70.62	105	155	200	320	385	550
86.50	85	125	165	260	310	450
105.9	70	105	140	210	260	380
129.7	55	85	110	175	205	290
158.9	45	70	95	145	165	250
194.6	...	60	80	120	140	195
Intermediate Gear on Ref. #4 Shaft Assembly, Figure 2						
238.4	...	45	60	95	115	160
291.9	...	35	50	80	90	130
357.5	...	30	40	65	75	105
437.9	...	25	30	50	60	90
536.3	...	20	25	45	50	75
656.8	...	17	20	35	40	60
804.5	...	13.8	18	30	35	50
985.3	...	11.4	15	25	30	40
1207	...	9.3	12.1	20	25	30

B. Remove bearing locknut, lock washer and keyed washer. Press bevel pinion out of bearing cage (toward pinion) and outer bearing. Remove bearing cups from bearing cage and remaining bearing cone from shaft.

12. LOW SPEED (BEVEL GEAR) SHAFT—Figure 6.

- Position drive upright and remove upper end cover or seal cage. Attach eye bolt(s) to low speed shaft assembly, sling and lift out of housing. Reposition housing and remove lower seal cage or end cover. Save shim gaskets for reference at reassembly.
- Remove upper bearing, grease retainer, spacer and bevel gear from shaft as an assembly, use press (umbrella stays on shaft). Upper bearing and grease retainer may be removed separately if service on bevel gear is not required. Remove lower bearing. Remove bevel gear key and umbrella if required.

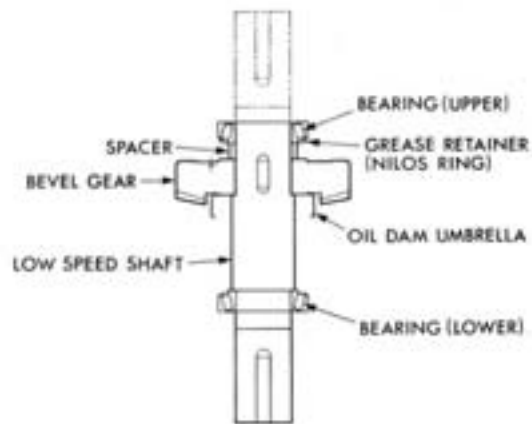


Figure 6 LOW SPEED (BEVEL GEAR) SHAFT ASSEMBLY

CLEANING, INSPECTION AND REPLACEMENT OF PARTS

13. Table 7 lists high speed shaft assemblies that require replacement as assemblies and not individual parts. The following instructions apply to servicing of reusable parts.

TABLE 7 — High Speed Shaft Keyless Bored Pinions and Non-Removable Bearings

Reduction	AGMA Ratio	DRIVE SIZE				
		284	305	326	357	388
Triple (AFX3)	38.44	Keyless †	Keyless †	...	...	...
	47.08	Keyless †	Keyless †	...	...	...
	57.66	Keyless †	Keyless †	...	...	...
	70.62	Keyless †	Keyless †	...	...	...
	86.50	Keyless †	Keyless †	...	...	...
Quadruple (AFX4)	238.4	Keyless †	Keyless †	Keyless †	...	Keyless
	291.9	Keyless †	Keyless †	Keyless †	...	Keyless
	357.5	Keyless †	Keyless †	Keyless †	...	Keyless
	437.9	Keyless †	Keyless †	Keyless †	...	...
	536.3	...	Keyless †	Keyless †	...	...

† The outer bearing of the shaft assembly is not removable.

14. CLEAN HOUSING, HEADS AND ATTACHMENTS.

- Remove gasket material from sealing surfaces.
- Remove all burrs.

- C. Clean oil chamber and all internal revolving elements with kerosene or solvent.
- D. Coat pipe plug threads with Permatex #3 before installing.

15. SEALS.

- A. Drive out old seals and remove old sealing compound from seal cage bores. DO NOT replace seals at this time.

16. BEARINGS.

- A. Wash the bearings in clean kerosene or solvent and then dry. Do not spin bearings for they may score due to lack of lubricant.
- B. Inspect bearings carefully and replace all that are worn.
- C. Use a wheel puller or press to remove the bearings. Apply force to the inner race only.
- D. DO NOT mount bearings next to intermediate shaft locknuts until the shaft assembly has been installed into the high speed head. Then mount bearing per Step 16E.
- E. Before mounting open ball or tapered roller bearings, heat in an oil bath or an oven to a maximum of 275°F(135°C) and then slide or press them tight against the shaft shoulder. CAUTION: Do not apply flame directly to bearings or rest them on the bottom of the heated container.
- F. After cooling, thoroughly coat all bearings with lubricating oil.

17. GEAR AND PINION REPLACEMENT.

- A. Wash the pinions and gears in clean kerosene or solvent and inspect for damaged or worn teeth.
- B. DO NOT mount pinions that had to be heated and removed (Step 9B), to permit removal of the shaft from the high speed head. Insert the assembled shaft (less pinion) into the head and then mount the pinion per Step 17C.
- C. **KEYED ELEMENTS** — Assemble straight-bored pinions (with keys) to the shaft from the chamfered side. Preheat pinions in an oil bath or an oven to a maximum of 275°F(135°C) and then press the pinion tight against the shaft shoulder. Check with a feeler gauge to see that there is no clearance.
- D. **KEYLESS ELEMENTS** — Replace keyless pinion shaft assemblies and straight bored gear shaft assemblies listed in Table 7 as a Factory assembly if either the pinion, gear, shaft or non-removable bearing is worn or damaged. **DO NOT mount taper-bored gear at this time.**

18. FASTENERS.

- A. Remount lock washers on external fasteners during reassembly. When replacing fasteners, use the identical grade and type as furnished in the original assembly. Note that the bevel pinion bearing cage fastener threads are coated with an adhesive.
- B. Replace used locknuts with new ones to ensure maximum holding capacity. Before mounting, dip the locknut in SAE 20 or heavier oil.

19. SHIM-GASKETS.

- A. Replace the used shim-gaskets with new ones. Shim-gaskets with minimum compressibility (see Table 1), are available from the Factory in thicknesses of .007, .009, .015 and .031 inches.

- B. Always place the one .015" shim-gasket against the seal cage or end cover when the seal cage or end cover is a stamping or against the housing when it is a casting for positive sealing as explained in Step 6F.

20. CLEAN AND OIL PARTS.

All parts must be clean. Pay particular attention to the inside of the housing to see that all foreign matter has been removed. Check to see that all worn parts have been replaced and that all gears and bearings are coated with oil.

REDUCER ASSEMBLY — PRELIMINARY

Steps 21 thru 23 are set forth here to eliminate repetition. As necessary the assembly instructions will refer back to these steps.

21. BEARING AXIAL FLOAT — Axial float measurements are not required if not shown in Table 3.

22. BEARING AXIAL FLOAT MEASUREMENT — Before checking axial float, torque fasteners to the appropriate value listed in Table 2. Determine the total shaft axial float with a dial indicator. Rotate shaft while applying axial force in both directions to measure axial float. Add or subtract shim-gaskets from the shim pack until measured axial float is within the limits shown in Table 3.

23. TIGHTEN TAPERED SHAFT LOCKNUT.

- A. After dipping locknut in oil and mounting, torque as follows:
Hold the locknut with an open end wrench and turn the high speed shaft extension with a spanner wrench to the torque specified in Table 6 (If the nut is accessible for a torque wrench, torque to value shown in Table 5.)

HIGH SPEED HEAD REASSEMBLY

The following steps apply to the shaft assemblies entirely supported in the high speed head. Refer to Figure 2 (shaft assemblies).

DOUBLE REDUCTION**24. SIZES 284 THRU 388.**

- A. For high speed shafts with pinion on shaft and with:
 1. Ball bearings—Simply slide the assembly into the high speed head. Mount the retaining ring on outer bearing and inner bearing, if so equipped.
 2. Tapered roller bearings—Insert the inner bearing outer race into inner wall of high speed head. Then insert the high speed shaft assembly and outer bearing outer race.
- B. For high speed shaft with unmounted pinion, follow preceding Step 1 or 2. Mount the bored pinion per Steps 17B and 17C.
- C. For Sizes 284 and 305 drives.
Install seal and seal cage with one .031" gasket as outlined in Steps 6D thru 6J.
- D. For Sizes 326 thru 388.
 1. Mount seal cage (without seal) with a total of at least .062" of shim-gaskets.
 2. Insert seal cage fasteners, torque to Table 2 values.

3. Adjust high speed shaft axial float per Step 22 and Table 3. Use only one .015" shim-gasket in the final shim pack. On Sizes 326 and 357, place the .015" shim-gasket against the seal cage. On Size 388, place the .015" shim-gasket against the drive housing.
4. Remove seal cage and install seal as outlined in Steps 6D thru 6J. Tighten fasteners to torque shown in Table 2.

TRIPLE REDUCTION

25. SIZES 284 THRU 326.

- A. Insert high speed shaft assembly through the outer wall and into the inner wall of the high speed head.
- B. Install seal and seal cage with one .031" gasket as outlined in Steps 6D thru 6J. Tighten fasteners to torque shown in Table 2.
- C. Dip the gear locknut in SAE 20 or heavier oil.
- D. See Figure 2. With the intermediate pinion and the adjacent bearing minus the bearing outer race retaining ring in place on intermediate #3 shaft (and key in taper), insert the shaft through (1) the inner wall of the high speed head, (2) bearing retaining ring, (3) taper-bored gear (and spacer for Size 284), (4) locknut (turn finger tight), (5) spacer, and (6) into the outer high speed head bearing bore.
- E. Mount retaining ring on inner bearing.
- F. Tap the outer bearing into the bore and onto the shaft. Temporarily mount spacer (Sizes 305 and 326) and end cover with two or three fasteners to hold shaft in place.
- G. Tighten locknut per Step 23.
- H. Remove end cover and seat inner race of the outer bearing. Re-install bearing spacer (Sizes 305 and 326). Mount end cover with one .031" gasket and tighten fasteners to torque shown in Table 2.

26. SIZES 357 THRU 388.

- A. For Size 357, see Steps 25A and 25B for high speed shaft assembly into head.
- B. For Size 388 high speed shaft assembly, first tap the high speed tapered bearing cup into the inner wall of the high speed head. Then insert the high speed shaft assembly and outer bearing outer race. Install seal cage (without seal) and sufficient shim-gaskets to obtain float. Tighten fasteners to torque shown in Table 2. Adjust high speed shaft axial float per Step 22 and Table 3. Use only one .015" shim-gasket in the final shim pack and place it against the high speed head. Remove seal cage and install seal as explained in Steps 6D thru 6J. Tighten fasteners to torque shown in Table 2.
- C. Dip the gear locknut in SAE 20 or heavier oil.
- D. See Figure 2. Insert intermediate #3 shaft subassembly with key in taper (less inner bearing outer race) through the inner wall of high speed head, taper-bored gear and locknut into the outer bearing bore. Tighten locknut finger tight.
- E. Insert inner bearing outer race into inner wall of high speed head and install keeper plate. Torque fasteners to Table 2 value.
- F. Insert bearing into high speed head and temporarily hold it in place with the end cover and two or three fasteners.

- G. Tighten locknut per Step 23.
- H. Remove end cover and seat outer bearing. Remount end cover with sufficient shim-gaskets to obtain float and torque fasteners to the value shown in Table 2.
- J. Adjust intermediate shaft axial float per Step 22 and Table 3. Use only one .015" shim-gasket in the final shim pack and place it against the high speed head.

27. SIZES 284 AND 305.

- A. Install #1 high speed shaft assembly per Steps 25A thru 25B.
- B. **SIZE 284** — Install #2 shaft as follows: Remove retaining ring from inner bearing OD. Insert key into the tapered shaft keyway. Hold the retaining ring, high speed gear and locknut (dipped in oil) between the walls of the high speed head. Install these parts as #2 shaft is passed through the high speed head from the inner wall. Pass the shaft through the high speed head an additional distance to allow installation of the retaining ring on the bearing. After retaining ring is installed, move shaft back to seat the retaining ring against the housing wall. Install inner spacer, outer bearing and outer spacer. Install one .031" gasket and end cover. Torque fasteners to value shown in Table 2. Tighten locknut per Step 23.
Size 305 — Install #2 shaft as follows: Insert key into the tapered shaft keyway. Hold the high speed gear, spacer and locknut (dipped in oil) between the walls of the high speed head. Install these parts as #2 shaft (with inner bearing installed) is passed through the high speed head from the inner wall. Install the retaining ring into the groove in the inner head wall. Install outer bearing and retaining ring on the shaft. Tighten locknut per Step 23. Install one .031" gasket and end cover. Torque fasteners to value shown in Table 2.
- C. Install #3 intermediate shaft assembly per Steps 25C thru 25H.

28. SIZE 326.

- A. Install #1 high speed shaft assembly per Steps 25A and 25B.
- B. Install #2 shaft as follows: Install the inner bearing and inner bearing sleeve into the inner wall of the high speed head. Insert key into the tapered shaft keyway. Hold the high speed gear between the walls of the high speed head. Install the gear as #2 shaft (with outer bearing installed) is passed through the high speed head from the outer wall. Install spacer against outer bearing. Install one .015" shim-gasket and end cover. Torque fasteners to value shown in Table 2. Install and tighten locknut per Step 23.
- C. Install #3 intermediate shaft assembly per Steps 25C thru 25H.

29. SIZES 357 THRU 388.

- A. Install #1 high speed shaft assembly per Steps 25A and 25B.
- B. Taper inner bearing outer race of 1st intermediate #2 shaft assembly into the inner wall of the high speed head (inner and outer race of bearing and inner bearing sleeve on Size 357).
- C. Dip gear locknut in SAE 20 or heavier oil.

- D. Insert 1st intermediate #2 shaft assembly with key in taper through high speed head, taper-bored gear, locknut and into inner bearing. Tighten locknut finger tight.
- E. Insert bearing, outer race (and spacer on Size 357) into high speed head and temporarily hold in place with end cover and two or three fasteners.
- F. Tighten locknut per Step 23.
- G. Remove end cover and seat inner bearing onto shaft. Remount end cover with sufficient shim-gaskets to obtain float and tighten fasteners to the value show in Table 2.
- H. Adjust intermediate shaft axial float per Step 22 and Table 3. Use only one .015" shim-gasket in the final shim pack and place it against the high speed head.
- J. Install 2nd intermediate #3 shaft assembly per Steps 26C thru 26H.

LOW SPEED END ASSEMBLY & INSTALLATION

30. BEVEL PINION ASSEMBLY AND INSTALLATION — Figures 2 & 5.

A. ASSEMBLY.

Assemble both bearing cups to bearing cage. Heat and assemble inner bearing cone with rollers large end towards pinion. Stand bevel pinion on end and assemble bearing cage onto pinion. Heat outer bearing cone, assemble to pinion shaft and allow assembly to cool. Install keyed washer, lock washer and bearing locknut. Tighten locknut until shaft axial float of .001" to .003" is achieved. Check outer bearing cone back face runout (must be .001" or less, tap high side to adjust) and recheck axial float. Lock bearing lock washer when bearing setting is correct.

B. INSTALLATION.

- 1. If original bevel pinion is being reassembled into drive, use same steel shimpack as removed at disassembly. If new bevel pinion is used, add or subtract shims from old shimpack (add if mounting distance of new pinion is greater) equal in thickness to change in mounting distance (etched on bevel gear). Use uncoated cage fasteners for temporary assembly (mounting distance adjustment may be required).
- 2. Wire tie shimpack to bearing cage flange, sling bevel pinion from eye nut and lower into housing bore (pinion assembly moves sideways in housing to engage bore after cage bolting flange clears housing front face). Remove shimpack wire ties, install cage fasteners, release sling load and tighten fasteners (temporary assembly).

31. LOW SPEED (BEVEL GEAR) SHAFT ASSEMBLY AND INSTALLATION.

A. ASSEMBLY — Figure 6.

Assemble oil dam umbrella and gear key to shaft (if removed). Heat bevel gear (275°F max) and assemble to shaft. Seat with press. Assemble shaft spacer and grease retainer to shaft. Heat upper bearing cone, assemble to shaft & seat bearing (grease retainer and shaft spacer must not be free to rotate). Heat and assemble lower bearing cone to shaft.

B. INSTALLATION.

- 1. Assemble lower seal cage or end cover (bearing cage on Sizes 305 and 357 with hollow shaft) to housing with shimpack of equal compressed thickness to that removed.

Install and tighten fasteners to torque specified in Table 2.

- 2. Position housing upright. Assemble oil dam (if previously removed) with new gasket to housing. Coat sealing surfaces of gasket inside of bolt circle (both sides) with Permatex #3 or equivalent sealant before assembly. Install and tighten oil dam fasteners to specified torque in Table 3. DO NOT over tighten.
- 3. Position housing upright, sling and carefully lower shaft assembly into housing. Assemble upper end cover or seal cage to drive with a shimpack of equal compressed thickness to that removed plus one additional .007" and .009" shim-gasket (to ensure shaft axial float on first bearing setting check). Install and tighten cage fasteners to specified torque.
- 4. Check low speed shaft axial float and remove shim-gaskets from upper cage shimpack to obtain .001" to .004" bearing preload. Reinstall cage, cage fasteners and tighten to specified torque.

32. BEVEL GEARSET BACKLASH AND CONTACT ADJUSTMENT.

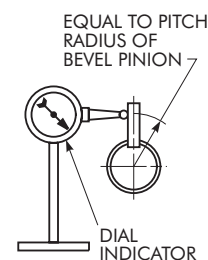
- A. Measure bevel gearset backlash at the pinion pitch radius (Table 8).

TABLE 8 — Bevel Pinion Pitch Radius

DRIVE SIZE	Pitch Radius – Inches
273	1.22
284	1.47
305	1.67
326	1.86
357	2.20
388	2.70

- 1. To measure backlash, wedge a key into the bevel pinion shaft helical gear keyseat as shown in Figure 7. Place a dial indicator squarely against the side of the key at the pinion pitch radius (Table 8).

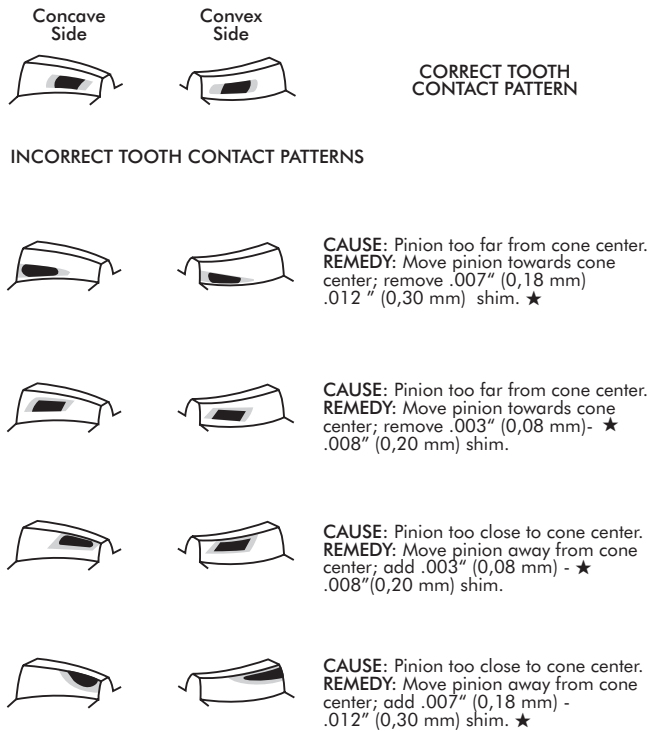
Figure 7 BEVEL PINION BACKLASH MEASUREMENT



- 2. Rotate the bevel pinion shaft back and forth while holding the bevel gear shaft immobile. Read the backlash (tooth clearance) on indicator. Required backlash is etched on outer diameter of the bevel gear. Measure at three locations, 120° apart on the gear and use the minimum measured value for reference at adjustment.
- 3. Acceptable backlash adjustment is etched backlash (on gear O.D.) to etched backlash + .005" at the minimum backlash condition. Remove/add shim-gaskets of equal thickness change to upper and lower shimpacks (to maintain bearing setting) to adjust backlash. Backlash

change is approximately 0.8 x shim-gasket thickness transfer. Backlash increases with shim-gasket transfer to upper shimpack.

- B. Coat a few adjacent bevel pinion teeth with bluing. Roll blued pinion teeth into mesh and oscillate pinion to transfer contact pattern onto gear teeth while rolling blued pinion teeth thru gear mesh. Refer to Figure 8 for correct tooth contact patterns and steps to be taken to obtain correct tooth contact (remove or add shims to bevel pinion cage shimpack). Recheck backlash.

Figure 8 BEVEL PINION TOOTH CONTACT PATTERNS


★ Use the smaller tolerances for gear diameters in the 6"-8" (152,4 mm) - (203,2 mm) range. Use the larger tolerances for gear diameters over 20" (508 mm). If correct tooth contact pattern cannot be achieved, consult Falk.

- C. With correct bevel gearset contact pattern and backlash settings, reinstall bevel pinion bearing cage fasteners with Loctite high strength thread locking compound (not needed if new coated fasteners are used at final assembly) and tighten to specified torque.
- D. Install low speed shaft oil seals, refer to Step 6. The lower seal cage must be removed from the drive to install the oil seal. This is best accomplished with the drive upside down.

HIGH SPEED END INSTALLATION

33. SIZE 273—ALL REDUCTIONS.

- A. Stand drive on end (properly supported) with high speed end up.
- B. Insert key into tapered shaft keyway of bevel pinion shaft.
- C. Install the taper-bored gear and all of the high speed end shaft assemblies simultaneously.
- D. Dip the gear locknut in SAE 20 or heavier oil and turn it onto the shaft.
- E. Tighten the locknut per one of the following methods:

1. Use a torque wrench to tighten locknut to the value specified in Table 5.
 2. Hold the locknut with the "short wrench" (Table 1). Temporarily assemble high speed bearing plate to housing (Steps H thru L) and turn the high speed shaft extension with a spanner wrench to the torque specified in Table 6. Turn high speed shaft CW on double reduction and CCW on triple reduction to tighten nut.
- F. Position one gasket on the housing face.
- G. On double reduction drives, remove the retaining ring from the outer high speed shaft bearing.
- H. Tap the high speed bearing plate into position on the high speed bearing and the housing dowels.
- J. Insert fasteners (with lock washers) and cross-tighten to torque specified in Table 2.
- K. Replace double reduction high speed bearing retaining ring.
- L. Replace high speed shaft oil seal and seal cage per Steps 6D thru 6K.

34. SIZES 284 THRU 388—ALL REDUCTIONS.

- A. Stand drive on end (properly supported) with high speed end up.
- B. Install high speed head gasket.
- C. Install three or four eye bolts into the tapped holes around the high speed head flange.
- D. Carefully lower the high speed head assembly into position on the housing and tap into place. Install threaded dowels in triple and quadruple reduction drives. DO NOT damage gear teeth.
- E. Insert fasteners and cross-tighten to the torque shown in Table 2.

35. MISCELLANEOUS ASSEMBLY.

- A. Install oil seals per Step 6 (if not previously installed). Reinstall dipstick.
- B. Position drive upright and pump specified quantity (Table 9) of NLG1 #2 bearing grease into grease lubricated low speed shaft bearings. Rotate high speed shaft while greasing bearings.

TABLE 9 — Low Speed Shaft Bearing Grease Requirements – lb

DRIVE SIZE	Bearing Location	Solid Shaft		Hollow Shaft
		Seal Cage	End Cover	Seal Cage
273	Upper ‡	.55	.70	.40
	Lower •	.70	1.00	.70
284	Upper ‡	.60	.90	.60
	Lower •	1.00	1.60	1.00
305	Upper ‡	.85	1.24	.62
	Lower •	1.00	1.60	1.00
326	Upper ‡	.70	1.18	.70
	Lower •	1.00	2.00	1.00
357	Upper ‡	1.44	1.96	.98
	Lower •	1.60	3.30	1.60
388	Upper ‡	2.60	3.60	2.60
	Lower •	3.00	5.00	3.00

‡ Quantity required to fill bearing & grease chamber. Excess will be forced past grease seal into gear case.

• Quantity includes 50% reserve supply above bearing. Lower bearing with end cover is normally oil lubricated. Quantity listed is for grease lubrication option.



INSTALLATION

36. REDUCER INSTALLATION.

- A. Reinstall accessories (if so equipped). Tighten fasteners to specified torque in Table 2.
- B. Turn gear train over by hand as a final check for internal or accessory interference. Readjust if necessary.
- C. Reinstall reducer. Refer to Manual 258-050 for installation instructions.
- D. Fill reducer with oil to level indicated on dipstick. Refer to Manual 258-050 for recommended lubricants and approximate oil quantities.
- E. Run reducer without load. If reducer temperature rises more than 75° F above ambient temperature in 4 hours, recheck shimming of bearings.
- F. After reducer runs satisfactorily, apply load. Inspect periodically until operation is deemed satisfactory. Follow preventive maintenance instructions in Manual 258-050.