TID/SNA -- 1918

REPORT NO.

TMP-124

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SUBJECT

ASSEMBLY PROCEDURE - TURBOPUMP ASSEMBLY - DEVELOPMENT P/N 1139350

DATE

3-20-72

WORK ORDER

1190-12-198

BY

P. Pare'/T. Petersen

CHK BY

DATE

SECTIONS

- SECTION 1.0 GENERAL REQUIREMENTS
- *(A) SECTION 2.0 ROTOR MACHINING ASSEMBLY, P/N 1139398
- *(B) SECTION 3.0 ROTOR LOW SPEED BALANCING ASSEMBLY, P/N 1139399
- *(C) SECTION 4.0 ROTOR HIGH SPEED BALANCING ASSEMBLY, P/N 1139400
- *(D) SECTION 5.0 TURBOPUMP ASSEMBLY, P/N 1139350

1.0 GENERAL REQUIREMENTS

- 1.1 The following documents and drawings of the latest issue in effect, form a part of this instruction to the extent indicated herein and/or to the extent specified on the appropriate drawing.

MIL-I-6866	Penetrant Inspect
AGC-STD-4869	Temperature Compensation
AGC-STD-9007	Cleaning
ASD-5040	Installation of Fittings
ASD-5215	Marking
ASD-5226	Bolt Torque Sequence
ASD-5227	Tube Bending
ASD-5228	Tube Flaring
ANS-9032	Quality Standard
MS-33540	Safety Wiring
Dwg 1139398	Rotor Machining Assembly
Dwg 1139399	Rotor Low Speed Balance Assembly
Dwg 1139400	Rotor High Speed Balance Assembly
Dwg 1139350	Turbopump Assembly

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*SECTIONS NOTED ON THE APPROPRIATE DRAWINGS ARE CALLED OUT AS FOLLOWS:

SECTION 2.0 is Section A
 SECTION 3.0 is Section B
 SECTION 4.0 is Section C
 SECTION 5.0 is Section D

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- 1.2 General Note References (G/N and) in the following procedure will be found on the appropriate drawing unless otherwise specified.
- 1.3 All components shall be cleaned prior to assembly to result in the cleanliness specified on the appropriate drawing.
- 1.4 An APL and PRR shall be maintained to define the "as-built" configuration of the assembly. The related PO, shop order, or NWA shall be entered on the APL for all new components and for all modified components.
- 1.5 Prior to or during assembly, assure acceptance of all components, any nonconformities noted to be recorded on the Historical IR.
- 1.6 Visually inspect all components, at time of assembly. Any evidence of physical damage shall be recorded on the Historical IR and dispositioned by engineering prior to use in the assembly.
- 1.7 Assembly to be accomplished under clean room conditions adequate to maintain cleanliness specified on appropriate drawing.
- 1.8 Proper handling of fixtures, tooling and protective closures shall be used at all times to protect the quality of the assembly.
- 1.9 Lubricate all threads with Molykote 321 prior to assembly.
- 1.10 Lubricate all pilots sparingly (wipe off excess with lint free wipe) with Molykote 321 prior to assembly. Mask adjoining surfaces prior to lubricating.

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- 1.11 Lubricate all splines with Molykote 321 prior to assembly.
- 1.12 "⬡" in column at right of page indicates a Section N8300 representative shall initial procedure when that step is completed. The first step completed each day shall be dated.
- 1.13 "◯" in column at right of page indicates a Department N7000 representative shall initial procedure when that step is completed. The first step each day shall be dated.
- 1.14 The equipment required for assembly will be checked by a Department N7000 representative where necessary to ensure calibration certification.

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2.0 ROTOR MACHINING ASSEMBLY, P/N 11393982.1 Assembly

- 2.1.1 Clamp impeller, 2nd stage 1139470-1 in cradle ass'y, T1050213.
- 2.1.2 Insert Tie Bolt 1139361-6 into impeller, 2nd stage. Ensure that pins in tie bolt enter holes in impeller.
- 2.1.3 Install spacer T1050207-1 on aft end of impeller 2nd stage.
- 2.1.4 Cool front end of turbine rotor subassembly 1139442-5 in LN₂ and warm Aft end of impeller 2nd stage to 250°F with heat gun (DO NOT HEAT TIE BOLT) and install turbine rotor into impeller 2nd stage.
- 2.1.5 Install spacer T1050207-1 on front end of impeller, 2nd stage.
- 2.1.6 Cool Aft end of pump rotor, subassembly 1139441-5 in LN₂ and warm front end of impeller, 2nd stage to 250°F with heat gun (DO NOT HEAT TIE BOLT) and install pump rotor into impeller, 2nd stage.
- 2.1.7 Warm ends of tie bolt with heat gun to remove moisture. Do not exceed 250°F.
- 2.1.8 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assy to 500°F in furnace and install onto pump rotor, subassy. When parts return to room temperature, remove tool.
- 2.1.9 Install lock washer 1139385-1 and nut 1139384-1 finger tight using wrench T1050254-1 onto front end of tie bolt. Do not bend lockwasher tabs.

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2.1.10 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assy to 500°F in furnace and install onto turbine rotor subassembly. When parts return to room temperature remove tool.

2.1.11 Install lockwasher 1139387-1 and nut 1139386-1 finger tight onto rear end of tie bolt. Do not bend lockwasher tabs.

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2.2 Bolt Stretcher Calibration (T1050263)

2.2.1 Hang cylinder T1050263 Item 2 (1138827-3) from crane in horizontal position.

2.2.2 Assemble bolt stretcher T1050263 Step 3.

2.2.3 Adjust clamp on cylinder so that assy. lies horizontal.

2.2.4 Hook up hand pump T1050263 Item 15 and associated equipment to cylinder.

2.2.5 Fill system with oil T1050263 Item 23 and bleed system of air.

2.2.6 Using hand pump extend cylinder ram to take up clearance between ram and collar on pull sleeve T1050258.

2.2.7 Using hand pump stretch assembly until pressure gage reads 3000 psi.

2.2.8 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand).

2.2.9 Set up dial indicator and record reading.

A = _____ in.

2.2.10 Using hand pump stretch assy until pressure gage reads 3000 psi and record dial indicator readings every 500 psi. Tabulate results in table.

PRESSURE PSI	INDICATOR READING B INS.	STRETCH B-A INS.
0	B = A =	
500		
1000		
1500		
2000		
2500		
3000

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2.2.11 Construct a graph of pressure/stretch and record stretch at 2555 psi and 2920 psi.

Stretch
B-A Ins.

Stretch at 2550 psi = C = _____ in. (Rear)

Stretch at 2920 psi = D = _____ in. (Front)

2.2.12 Release oil pressure and disassemble bolt stretcher. Leave hand pump and cylinder hooked up and filled with oil.

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2.3 Stretching Tie Bolt

- 2.3.1 Hang cylinder T1050263 Item 2 (1138827-3) from crane in horizontal position.
- 2.3.2 Insert wrench T1050260-1 into thrust sleeve T1050259-1 and assemble thrust sleeve to cylinder.
- 2.3.3 Insert free end of thrust sleeve into inducer. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely inside inducer.
- 2.3.4 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.
- 2.3.5 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.
- 2.3.6 Using hand pump extend cylinder ram to take up clearance between ram and collar on pull sleeve T1050258-1. Ensure that thrust sleeve is seated squarely against impeller, 1st stage, and aligned freely inside inducer.
- 2.3.7 Using hand pump stretch tie bolt until pressure gage reads 3000 psi.
- 2.3.8 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)
- 2.3.9 Record dial indicator reading, $E = \underline{\hspace{2cm}}$ IN.
- 2.3.10 Computer and record, $F = E + D + .015 = \underline{\hspace{2cm}}$ IN.
- 2.3.11 Using hand pump stretch bolt until indicator reading is F. Record actual $F = \underline{\hspace{2cm}}$ In.
Record Cylinder Pressure = $\underline{\hspace{2cm}}$ psi.

NOTE: DO NOT EXCEED 3700 psi.

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2.3.12 Turn nut 1139384-1 up by hand using wrench
T1050260-1.

2.3.13 Release oil pressure until clearance between ram
and collar on pull sleeve is zero. (Verify by
being just able to rotate thrust sleeve by hand.)

2.3.14 Record dial indicator reading, $G = \underline{\hspace{1cm}}$ In.

2.3.15 Compute and record, $H = G - E = \underline{\hspace{1cm}}$ In.

2.3.16 If $H = .015 \pm .001$ go to Step 2.3.24. If not
continue with Step 2.3.17.

2.3.17 Compute and record $.015 - H = \underline{\hspace{1cm}}$ In.

2.3.18 Using hand pump stretch bolt until indicator
reading is $F_1 = F + .015 - H = \underline{\hspace{1cm}}$ In.
(Nut may have to be loosened.)

Record actual $G_1 = \underline{\hspace{1cm}}$ In.

Record cylinder pressure $\underline{\hspace{1cm}}$ psi.

NOTE: DO NOT EXCEED 3700 PSI.

2.3.19 Turn nut up by hand using wrench.

2.3.20 Release oil pressure until clearance between ram
and collar on pull sleeve is zero. Verify as in
2.3.13.

2.3.21 Record indicator reading, $G_1 = \underline{\hspace{1cm}}$ In.

2.3.22 Compute and record $H_1 = G_1 - F = \underline{\hspace{1cm}}$ In.

2.3.23 If $H_1 = .015 \pm .001$ go to Step 2.3.24. If not
repeat Steps 2.3.17 through 2.3.23 until it is.
Record all values each time.

2.3.24 Remove dial indicator and unscrew measuring rod
T1050261-1.

2.3.25 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher. Do not bend lockwasher tabs.

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2.3.26 Set up bolt stretcher on crane at turbine location.

2.3.27 Insert free end of thrust sleeve T1050259-1 into turbine, 2nd stage.

2.3.28 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.

2.3.29 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

2.3.30 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against turbine, 1st stage and aligned freely inside turbine, 2nd stage.

2.3.31 Using hand pump stretch tie bolt until pressure gage reads 2750 psi.

2.3.32 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)

2.3.33 Record dial indicator reading, $J = \underline{\hspace{1cm}}$ In.

2.3.34 Compute and record $K = J + C + .009 = \underline{\hspace{1cm}}$ In.

2.3.35 Using hand pump stretch bolt until indicator reading is K. Record actual $K = \underline{\hspace{1cm}}$ In.
Record Cylinder Pressure = $\underline{\hspace{1cm}}$ psi.

NOTE: DO NOT EXCEED 3700 PSI.

2.3.36 Turn nut 1139386-1 up by hand using wrench T1050260-1.

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2.3.37 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)

2.3.38 Record dial indicator reading, $L = \underline{\hspace{2cm}}$ In.

2.3.39 Compute and record $M = L - K = \underline{\hspace{2cm}}$ In.

2.3.40 If $M = .009 \pm .001$ go to step 2.3.47. If not continue with Step 2.3.41.

2.3.41 Compute and record $.009 - N = \underline{\hspace{2cm}}$ In.

2.3.42 Using hand pump stretch bolt until indicator reading is $K_1 = K + .009 - N = \underline{\hspace{2cm}}$ In. (Nut may have to be loosened.)

Record actual $L_1 = \underline{\hspace{2cm}}$ In.

Record cylinder pressure $\underline{\hspace{2cm}}$ psi.

NOTE: DO NOT EXCEED 3700 PSI.

2.3.43 Turn nut up by hand using wrench.

2.3.44 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 2.3.37.

2.3.45 Record dial indicator reading $L_1 = \underline{\hspace{2cm}}$ In.

2.3.46 Compute and record $M_1 = L_1 - J = \underline{\hspace{2cm}}$ In. If $M_1 = .009 \pm .001$, go to Step 2.3.47. If not repeat Steps 2.3.40 through 2.3.46 until it is. Record all values each time.

2.3.47 Remove dial indicator and unscrew measuring rod T1050261-1.

2.3.48 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.

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2.3.49 Cool spinner 1139383-1 or 1139443-1 in LN₂ and install on inducer 1139441-5. Record P/N of spinner used. P/N _____.

2.3.50 When parts return to room temperature install washer 1139463-1 and bolt 1139464-1. Torque bolt to drawing requirements. Do not bend lockwasher tabs.

2.3.51 Remove rotor assembly from cradle.

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2.4 Disassembly

- 2.4.1 Clamp rotor assembly in cradle assembly T1050213 and set up bolt stretcher on crane at turbine location.
- 2.4.2 Insert free end of thrust sleeve T1050259-1 into turbine, 2nd stage.
- 2.4.3 Install spacer T1050262-1 into pull sleeve T1050258-1 and thread onto end of tie bolt finger tight and then back it out 1 turn.
- 2.4.4 Thread measuring rod T1050261-1 into end of tie bolt, and set up dial indicator.
- 2.4.5 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against turbine, 1st stage and aligned freely inside turbine, 2nd stage.
- 2.4.6 Using hand pump stretch tie bolt until pressure is at cylinder pressure in step 2.3.35 or 2.3.42 whichever is higher.
NOTE: DO NOT EXCEED 3700 PSI.
- 2.4.7 Back off nut 1139386-1 by using wrench T1050260-1.
- 2.4.8 Remove dial indicator and unscrew measuring rod T1050261-1.
- 2.4.9 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
- 2.4.10 Remove nut 1139386-1 and lockwasher 1139387-1 by hand.
- 2.4.11 Assemble puller T1050265-1 on cap retaining 1139430-1 and remove cap.

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- 2.4.12 Assemble puller T1050231-2 on turbine, 2nd stage and remove turbine rotor subassembly 1139442.
- 2.4.13 Remove spacer T1050207-1.
- 2.4.14 Remove nuts 61170-1032 18 places from front of turbine rotor subassembly 1139442 using wrench T1050209-1. Engage studs 1139357-1 with wrench T1050209-1 to ensure that they did not turn.
- 2.4.15 Press turbine rotors apart in arbor press using arbor plates T1050245-1.
- 2.4.16 Unscrew bolt 1139464-1 and remove washer 1139463-1 from spinner.
- 2.4.17 Install puller T1050242-1 onto spinner and remove spinner from inducer.
- 2.4.18 Set up bolt stretcher on crane at pump location.
- 2.4.19 Insert free end of thrust sleeve T1050259-1 into inducer.
- 2.4.20 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.
- 2.4.21 Thread measuring rod T1050261-1 into end of tie bolt and set up dia indicator.
- 2.4.22 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against impeller, 1st stage and aligned freely inside inducer.
- 2.4.23 Using hand pump stretch tie bolt until pressure is at cylinder pressure in Step 2.3.11 or 2.3.18 whichever is higher. NOTE: DO NOT EXCEED 3700 PSI.
- 2.4.24 Back off nut 1139384-1 by using wrench T1050260-1.
- 2.4.25 Remove dial indicator and unscrew measuring rod T1050261-1.

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2.4.26 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher.

2.4.27 Remove nut 1139384-1 and lockwasher 1139385-1.

2.4.28 Assemble puller T1050239-1 on cap retaining
1139430-1 and remove cap.

2.4.29 Assemble clamping tool T1050208-1 between tie
bolt and impeller 2nd stage.

2.4.30 Assemble puller T1050232 Step 1 on inducer and
remove pump rotor, subassembly 1139441.

2.4.31 Remove spacer T1050207-1.

2.4.32 Remove nuts 61170-1032 12 places from pump
rotor, subassembly 1139441.

2.4.33 Assemble puller T1050232 Step 2 between inducer
and impeller, 1st stage and remove inducer.

2.4.34 Remove tie bolt 1139361-1 from impeller 2nd
stage.

2.4.35 Disassemble tie bolt stretcher T1050263 and
rebox.

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3.0 ROTOR LOW SPEED BALANCE ASSEMBLY - P/N 11393993.1 Assembly (Beginning at Step 5 on 1139399)

3.1.1 Put insert 1139437-1 onto tool T1050222-1 and reduce O/D of insert to just fit gage T1050271-1. Cool insert and tool assy in LN₂ and install in front end of impeller, 2nd stage 1139470-1. When parts return to room temperature remove tool T1050222-1.

3.1.2 Put insert 1139437-2 onto tool T1050222-1 and reduce O/D of insert to just fit gage T1050271-1. Cool insert and tool assy in LN₂ and install in aft end of impeller, 2nd stage. When parts return to room temperature remove tool.

3.1.3 Set up impeller, 2nd stage 1139470-1 vertically with front end down on fixture T1050270-1 supported on arbor press.

3.1.4 Cool tie bolt 1139361-1 in LN₂ and install in impeller, 2nd stage by hand until pins in the bolt enter holes in impeller. Complete assembly with arbor press.

3.1.5 Remove screws from front and aft of impeller, 2nd stage as required off G/N 7 on 1139470. Add screws to adaptor 1139525-1 as required off G/N 13 on 1139399.

3.1.6 Cool aft end of impeller, 2nd stage by pouring LN₂ down hole in impeller shaft.

3.1.7 Install spacers 1138728-3 (2 required) and bearing 12997 onto impeller, 2nd stage, Ensure that match marks on spacers and high spot marks on bearing inner races are aligned with $\theta = 0^\circ$ (#1 balance screw hole) on impeller.

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- 3.1.8 Set up impeller, 2nd stage vertically with aft end down and cool front end by pouring LN_2 down hole in impeller shaft.
- 3.1.9 Install spacers 1138728-3 (2 required) and bearing 12997 onto impeller, 2nd stage. Ensure that match marks on spacers and high spot marks on bearing inner race are aligned with $\theta = 0^\circ$. (#1 balance screw hole).
- 3.1.10 Clamp impeller, 2nd stage in cradle assembly T1050-213 and warm both ends of tie bolt with heat gun to remove moisture. Do not exceed $250^\circ F$.
- 3.1.11 Cool adaptor 1139525-1 in LN_2 and install on front end of impeller, 2nd stage. Ensure that match marks on adapter is aligned with $\theta = 0^\circ$ on impeller.
- 3.1.12 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assy to $500^\circ F$ in furnace and install on adaptor 1139525-1. When parts return to room temperature remove tool.
- 3.1.13 Install lockwasher 1139385-1 and nut 1139384-1 onto front end of tie bolt finger tight. Do not bend lockwasher tabs.
- 3.1.14 Cool adaptor 1139526-1 in LN_2 and install on aft end of impeller, 2nd stage.
- 3.1.15 Install cap, retaining 1139430-1 onto tool T1050-249-1 and heat assy to $500^\circ F$ in furnace and install on adaptor 1139526-1. When parts return to room temperature remove tool.
- 3.1.16 Install lockwasher 1139387-1 and nut 1139386-1 onto aft end of tie bolt finger tight. Do not bend lockwasher tabs.

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- 3.1.17 Hang Cylinder T1050263 Item 2 from crane in horizontal position.
- 3.1.18 Insert wrench T1050260-1 into thrust sleeve T1050259-1 and assemble thrust sleeve to cylinder.
- 3.1.19 Hook up hand pump T1050263 Item 15 and associated equipment to cylinder.
- 3.1.20 Fill system with oil T1050263 Item 23 and bleed system of air.
- 3.1.21 Insert free end of thrust sleeve over adaptor 1139525-1. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely against adaptor.
- 3.1.22 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.
- 3.1.23 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.
- 3.1.24 Using hand pump extend cylinder ram to take up clearance T1050258-1. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 3.1.25 Using hand pump stretch tie bolt until pressure gage reads 3000 psi.
- 3.1.26 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)
- 3.1.27 Record dial indicator reading, $E = \underline{\hspace{2cm}}$ in.
- 3.1.28 Compute and record, $F = E + D + .015 = \underline{\hspace{2cm}}$ in.
- 3.1.29 Using hand pump stretch bolt until indicator reading is F. Record actual $F = \underline{\hspace{2cm}}$ in.
Record cylinder pressure = $\underline{\hspace{2cm}}$ psi.
- NOTE: DO NOT EXCEED 3700 psi.

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3.1.30 Turn nut 1139384-1 up by hand using wrench
T1050260-1.

3.1.31 Release oil pressure until clearance between ram
and collar on pull sleeve is zero. (Verify by
being just able to rotate thrust sleeve by hand.)

3.1.32 Record dial indicator reading, $G = \underline{\hspace{2cm}}$ in.

3.1.33 Compute and record, $H = G - E = \underline{\hspace{2cm}}$ IN.

3.1.34 If $H = .015 \pm .001$ go to Step 3.1.42. If not
continue with step 3.1.35.

3.1.35 Compute and record $.015 - H = \underline{\hspace{2cm}}$ in.

3.1.36 Using hand pump stretch bolt until indicator
reading is $F_1 = F + .015 - H = \underline{\hspace{2cm}}$ in.
(Nut may have to be loosened.)

Record Actual $G_1 = \underline{\hspace{2cm}}$ in.

Record cylinder pressure psi.

NOTE: DO NOT EXCEED 3700 PSI.

3.1.37 Turn nut up by hand using wrench.

3.1.38 Release oil pressure until clearance between ram
and collar on pull sleeve is zero. Verify as in
3.1.31.

3.1.39 Record indicator reading, $G_1 = \underline{\hspace{2cm}}$ in.

3.1.40 Compute and record $H_1 = G_1 - F = \underline{\hspace{2cm}}$ in.

3.1.41 If $H_1 = .015 \pm .001$ go to step 3.1.42. If not
repeat steps 3.1.35 through 3.1.41 until it is.
Record all values each time.

3.1.42 Remove dial indicator and unscrew measuring rod
T1050261-1.

3.1.43 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher. Do not bend lockwasher tabs.

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- 3.1.44 Insert free end of thrust sleeve T1050259-1 over adaptor 1139526-1.
- 3.1.45 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.
- 3.1.46 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.
- 3.1.47 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor, and aligned freely against adaptor.
- 3.1.48 Using hand pump stretch tie bolt until pressure gage reads 2750 psi.
- 3.1.49 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)
- 3.1.50 Record dial indicator reading, $J = \underline{\hspace{1cm}}$ in.
- 3.1.51 Compute and record $K = J + C + .009 = \underline{\hspace{1cm}}$ in.
- 3.1.52 Using hand pump stretch bolt until indicator reading is K. Record actual $K = \underline{\hspace{1cm}}$ in.
Record cylinder pressure = $\underline{\hspace{1cm}}$ psi.
NOTE: DO NOT EXCEED 3700 PSI.
- 3.1.53 Turn nut 1139386-1 up by hand using wrench T1050260-1.
- 3.1.54 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)

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3.1.55 Record dial indicator reading, $L = \underline{\hspace{1cm}}$ in. 3.1.56 Compute and record $M = L - K = \underline{\hspace{1cm}}$ in. 3.1.57 If $M = .009 \pm .001$ go to Step 3.1.64. If not continue with step 3.1.58. 3.1.58 Compute and record $.009 - N = \underline{\hspace{1cm}}$ in. 3.1.59 Using hand pump stretch bolt until indicator reading is $K_1 = K + .009 - N = \underline{\hspace{1cm}}$ in.
(Nut may have to be loosened.) Record actual $L_1 = \underline{\hspace{1cm}}$ in.Record cylinder pressure $\underline{\hspace{1cm}}$ psi

NOTE: DO NOT EXCEED 3700 PSI.

3.1.60 Turn nut up by hand using wrench.

3.1.61 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 3.1.54.

3.1.62 Record dial indicator reading $L_1 = \underline{\hspace{1cm}}$ in. 3.1.63 Compute and record $M_1 = L_1 - J = \underline{\hspace{1cm}}$ in.
If $M_1 = .009 \pm .001$ go to Step 3.1.64. If not repeat Steps 3.1.58 through 3.1.63 until it is.
Record all values each time.

3.1.64 Remove dial indicator and unscrew measuring rod T1050261-1.

3.1.65 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.

3.1.66 Remove impeller assembly from cradle.

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3.2 Disassembly of Step 5

- 3.2.1 Clamp impeller assembly in cradle assembly
T1050213. Set up bolt stretcher at aft end of
impeller, 2nd stage.
- 3.2.2 Insert free end of thrust sleeve T1050259-1 over
Adaptor 1139526-1.
- 3.2.3 Install spacer T1050262-1 into pull sleeve
T1050258 and thread onto end of tie bolt finger
tight and then back it out 1 turn.
- 3.2.4 Thread measuring rod T1050261-1 into end of tie
bolt and set up dial indicator.
- 3.2.5 Using hand pump extend ram to take up clearance
between ram and collar on pull sleeve. Ensure
that thrust sleeve is seated squarely against
adaptor and aligned freely against adaptor.
- 3.2.6 Using hand pump stretch tie bolt until pressure
is at cylinder pressure in Step 3.1.52 or 3.1.59
whichever is higher.
NOTE: DO NOT EXCEED 3700 psi.
- 3.2.7 Back off nut 1139386-1 by using wrench T1050260-1.
- 3.2.8 Remove dial indicator and unscrew measuring rod
T1050261-1.
- 3.2.9 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher.
- 3.2.10 Set up bolt stretcher on crane at front end of
impeller, 2nd stage.
- 3.2.11 Insert free end of thrust sleeve T1050259-1 over
adaptor 1139525-1.

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3.2.12 Thread pull sleeve T1050258-1 onto end of tie bolt
finger tight and then back it out 1 turn.

3.2.13 Thread measuring rod T1050261-1 into end of tie bolt
and set up dial indicator.

3.2.14 Using hand pump extend ram to take up clearance
between ram and collar on pull sleeve. Ensure
that thrust sleeve is seated squarely against
adaptor and aligned freely against adaptor.

3.2.15 Using hand pump stretch tie bolt until pressure is
at cylinder pressure in step 3.1.27 or 3.1.34,
whichever is higher.

NOTE: DO NOT EXCEED 3700 psi.

3.2.16 Back off nut 1139384-1 by using wrench T1050260-1.

3.2.17 Remove dial indicator and unscrew measuring rod
T1050261-1.

3.2.18 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher.

3.2.19 Remove nut 1139384-1 and lockwasher 1139385-1.

3.2.21 Assemble puller T1050244 Step 2 onto rotor and
remove adapter 1139525-1.

3.2.20 Assemble puller T1050239-1 on retaining cap
1139430-1 and remove cap.

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3.3 Assembly of Step 6

- 3.3.1 Install shim 1139407-1 onto front end of impeller 2nd stage.
- 3.3.2 Cool aft end of pump rotor, subassembly 1139441-5 in LN_2 and warm front end of impeller, 2nd stage to 250°F with heat gun (do not heat tie bolt) and install pump rotor into impeller, 2nd stage.
- 3.3.3 Warm ends of tie bolt with heat gun to remove moisture. Do not exceed 250°F.
- 3.3.4 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assy to 500°F in furnace and install onto pump rotor, subassembly. When parts return to room temperature remove tool.
- 3.3.5 Install lockwasher 1139385-1 and nut 1139384-1 finger tight using wrench T1050254-1 onto front end of tie bolt. Do not bend lockwasher tabs.
- 3.3.6 Set up bolt stretcher at front end of inducer.
- 3.3.7 Insert free end of thrust sleeve into inducer. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely inside inducer.
- 3.3.8 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.
- 3.3.9 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.
- 3.3.10 Using hand pump extend cylinder ram to take up clearance between ram and collar on pull sleeve T1050258-1. Ensure that thrust sleeve is seated squarely against impeller, 1st stage, and aligned freely inside inducer.

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- 3.3.11 Using hand pump stretch tie bolt until pressure gage reads 3000 spi.
- 3.3.12 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)
- 3.3.13 Record dial indicator reading, $E = \underline{\hspace{1cm}}$ in.
- 3.3.14 Compute and record, $F = E + D + .015 = \underline{\hspace{1cm}}$ in.
- 3.3.15 Using hand pump stretch bolt until indicator reading is F. Record actual $F = \underline{\hspace{1cm}}$ in.
Record cylinder pressure = psi.
NOTE: DO NOT EXCEED 3700 PSI.
- 3.3.16 Turn nut 1139384-1 up by hand using wrench T1050260-1.
- 3.3.17 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)
- 3.3.18 Record dial indicator reading, $G = \underline{\hspace{1cm}}$ in.
- 3.3.19 Compute and record, $H = G - E = \underline{\hspace{1cm}}$ in.
- 3.3.20 If $H = .015 \pm .001$ go to step 3.3.28. If not continue with Step 3.3.21.
- 3.3.21 Compute and record $.015 - H = \underline{\hspace{1cm}}$ in.
- 3.3.22 Using hand pump stretch bolt until indicator reading is $F_1 = F + .015 - H = \underline{\hspace{1cm}}$ in.
(Nut may have to be loosened.)
Record actual $G_1 = \underline{\hspace{1cm}}$ in.
Record cylinder pressure psi.
NOTE: DO NOT EXCEED 3700 PSI.

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- 3.3.23 Turn nut up by hand using wrench.
- 3.3.24 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 3.3.17.
- 3.3.25 Record indicator reading, $G_1 = \underline{\hspace{2cm}}$ in.
- 3.3.26 Compute and record $H_1 = G_1 - F = \underline{\hspace{2cm}}$ in.
- 3.3.27 If $H_1 = .015 \pm .001$ go to step 3.3.28. If not repeat steps 3.3.21 through 3.3.27 until it is. Record all values each time.
- 3.3.28 Remove dial indicator and unscrew measuring rod T1050261-1.
- 3.3.29 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.
- 3.3.30 Cool spinner 1139383-1 in LN_2 and install on inducer (Pump Rotor Subassy 1139441).
- 3.3.31 When parts return to room temperature install washer 1139463-1 and bolt 1139464-1. Torque bolt to drawing requirements. Do not bend lockwasher tabs.
- 3.3.32 Insert free end of thrust sleeve T1050259-1 over adaptor 1139526-1.
- 3.3.33 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.
- 3.3.34 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

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- 3.3.35 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 3.3.36 Using hand pump stretch tie bolt until pressure gage reads 2750 psi.
- 3.3.37 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)
- 3.3.38 Record dial indicator reading, $J = \underline{\hspace{2cm}}$ in.
- 3.3.39 Compute and record $K = J + C + .009 = \underline{\hspace{2cm}}$ in.
- 3.3.40 Using hand pump stretch bolt until indicator reading is K. Record actual $K = \underline{\hspace{2cm}}$ in. Record cylinder pressure = $\underline{\hspace{2cm}}$ psi.
NOTE: DO NOT EXCEED 3700 psi.
- 3.3.41 Turn nut 1139386-1 up by hand using wrench T1050260-1.
- 3.3.42 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)
- 3.3.43 Record dial indicator reading, $L = \underline{\hspace{2cm}}$ in.
- 3.3.44 Compute and record $M = L - K = \underline{\hspace{2cm}}$ in.
- 3.3.45 If $M = .009 \pm .001$ go to Step 3.3.52. If not continue with Step 3.3.46.
- 3.3.46 Compute and record $.009 - N = \underline{\hspace{2cm}}$ in.
- 3.3.47 Using hand pump stretch bolt until indicator reading is $K_1 = K + .009 - N = \underline{\hspace{2cm}}$ in. (Nut may have to be loosened.)
Record actual $L_1 = \underline{\hspace{2cm}}$ in.
Record cylinder pressure $\underline{\hspace{2cm}}$ psi
NOTE: DO NOT EXCEED 3700 PSI.

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3.3.48 Turn nut up by hand using wrench.

3.3.49 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 3.3.42.

3.3.50 Record dial indicator reading, $L_1 =$ _____ in.

3.3.51 Compute and record $M_1 = L_1 - J =$ _____ in.

If $M_1 = .009 \pm .001$ go to step 3.3.52. If not repeat Steps 3.3.45 through 3.3.51 until it is. Record all values each time.

3.3.52 Remove dial indicator and unscrew measuring rod T1050261-1.

3.3.53 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.

3.3.54 Remove impeller assembly from cradle.

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3.4 DISASSEMBLY OF STEP 6

- 3.4.1 Clamp impeller assembly in cradle assembly T1050213. Set up bolt stretcher at aft end of second stage impeller.
- 3.4.2 Insert free end of thrust sleeve T1050259-1 over adaptor 1139526-1.
- 3.4.3 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.
- 3.4.4 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.
- 3.4.5 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 3.4.6 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 3.1.52 or 3.1.59, whichever is higher.
- 3.4.7 Back off nut 1139386-1 by using wrench T1050260-1.
- 3.4.8 Remove dial indicator and unscrew measuring rod T1050261-1.
- 3.4.9 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
- 3.4.10 Remove nut 1139386 and lockwasher 1139387.
- 3.4.11 Assemble puller T1050265-1 on retaining cap 1139430-1 and remove cap.
- 3.4.12 Install puller T1050244 step 1 onto rotor and remove adaptor 1139526-1.
- 3.4.13 Remove impeller assembly from cradle.

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3.5 ASSEMBLY OF STEP 7

- 3.5.1 Clamp impeller assembly in cradle assembly T1050213.
- 3.5.2 Cool front end of turbine rotor subassembly 1139442 in LN₂ and warm rear end of second stage impeller to 250° F with heat gun (do not heat tiebolt) and install turbine rotor into second stage impeller.
- 3.5.3 Warm end of tiebolt with heat gun to remove moisture. Do not exceed 250°F.
- 3.5.4 Install retaining cap 1139430-1 onto tool T1050249-1 and heat assembly to 500° F in furnace and install onto turbine rotor subassembly. When parts return to room temperature, remove tool.
- 3.5.5 Install lockwasher 1139387-1 and nut 1139386-1 finger tight. Do not bend lockwasher tabs.
- 3.5.6 Set up bolt stretcher on crane at turbine location.
- 3.5.7 Insert free end of thrust sleeve T1050259-1 into second stage turbine.
- 3.5.8 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.
- 3.5.9 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.
- 3.5.10 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against first stage turbine and aligned freely inside second stage turbine.
- 3.5.11 Using hand pump, stretch tiebolt until pressure gage reads 2750 psi.

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3.5.12 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)

3.5.13 Record dial indicator reading, $J =$ _____ in.

3.5.14 Compute and record $K = J + C + .009 =$ _____ in.

3.5.15 Using hand pump, stretch bolt until indicator reading is K .
Record actual $K =$ _____ in.
Record cylinder pressure = _____ psi.
NOTE: DO NOT EXCEED 3700 PSI.

3.5.16 Turn nut 1139386-1 up by hand using wrench T1050260-1.

3.5.17 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)

3.5.18 Record dial indicator reading, $L =$ _____ in.

3.5.19 Compute and record $M = L - K =$ _____ in.

3.5.20 If $M = .009 \pm .001$, go to step 3.5.27. If not, continue with step 3.5.21.

3.5.21 Compute and record $.009 - N =$ _____ in.

3.5.22 Using hand pump, stretch bolt until indicator reading is K_1 .
 $K_1 = K + .009 - N =$ _____ in.
(Nut may have to be loosened.)
Record actual $L_1 =$ _____ in.
Record cylinder pressure _____ psi.
NOTE: DO NOT EXCEED 3700 PSI.

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3.5.23 Turn nut up by hand using wrench.

3.5.24 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify as in step 3.5.17.)

3.5.25 Record dial indicator reading $L_1 =$ _____ in.

3.5.26 Compute and record $M_1 = L_1 - J =$ _____ in.
 If $M_1 = .009 \pm .001$ go to step 3.5.27. If not, repeat steps 3.5.20 through 3.5.26 until it is. Record all values each time.

3.5.27 Remove dial indicator and unscrew measuring rod T1050261-1.

3.5.28 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
 Do not bend lockwasher tabs,

3.5.29 Remove rotor assembly from cradle.

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3.6 Disassembly of Step 7

3.6.1 Clamp rotor assembly in cradle assembly T1050213 and set up bolt stretcher on crane at turbine location.

3.6.2 Insert free end of thrust sleeve T1050259-1 into turbine, 2nd stage.

3.6.3 Install spacer T1050262-1 into pull sleeve T1050258-1 and thread onto end of tie bolt finger tight and then back it out 1 turn.

3.6.4 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

3.6.5 Using hand pump extend ram to takeup clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against turbine, 1st stage and aligned freely inside turbine 2nd stage.

3.6.6 Using hand pump stretch tie bolt until pressure is at cylinder pressure in Step 3.5.14 or 3.5.21 whichever is higher.

NOTE: DO NOT EXCEED 3700 PSI.

3.6.7 Back off nut 1139386-1 by using wrench T1050260-1.

3.6.8 Remove dial indicator and unscrew measuring rod T1050261-1.

3.6.9 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.

3.6.10 Remove nut 1139386-1 and lockwasher 1139387-1.

3.6.11 Assemble puller T1050265-1 on cap retaining 1139430-1 and remove cap.

3.6.12 Assemble puller T1050231-2 on turbine, 2nd stage and remove turbine rotor, subassembly 1139442.

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3.6.13 Unscrew bolt 1139464-1 and remove washer 1139463-1 from spinner.

3.6.14 Install puller T1050242-1 onto spinner and remove spinner from inducer.

3.6.15 Set up bolt stretcher on crane at pump location.

3.6.16 Insert free end of thrust sleeve T1050259-1 into inducer.

3.6.17 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.

3.6.18 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

3.6.19 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against impeller, 1st stage and aligned freely inside inducer.

3.6.20 Using hand pump stretch tie bolt until pressure is at cylinder pressure in step 3.3.15 or 3.3.22 whichever is higher. NOTE: DO NOT EXCEED 3700 PSI.

3.6.21 Back off nut 1139384-1 by using wrench T1050260-1.

3.6.22 Remove dial indicator and unscrew measuring rod T1050261-1.

3.6.23 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.

3.6.24 Remove nut 1139384-1 and lockwasher 1139385-1.

3.6.25 Assemble puller T1050239-1 on cap retaining 1139430-1 and remove cap.

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- 3.6.26 Assemble clamping tool T1050208-1 between tie bolt and impeller 2nd stage.
- 3.6.27 Assemble puller T1050232 Step 1 on inducer and remove pump rotor, subassembly 1139441.
- 3.6.28 Remove shim 1139407-1.
- 3.6.29 Remove impeller, 2nd stage from cradle.
- 3.6.30 Install impeller, 2nd stage, in arbor press using tool T1050233-1 to press against inboard spacer 1138728-3 at aft end of impeller and press off 2 spaces and bearing.
- 3.6.31 Reverse impeller in arbor press and using tool T1050233-1 to press against inboard spacer 1138728-3 at front end of impeller press off 2 spaces and bearing.
- 3.6.32 Disassemble tie bolt stretcher T1050263 and rebox.
- 3.6.33 Complete tables of balance screw weight and unbalance per plane.

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SCREW EIGHT. GRS.										
	STEP 1		STEP 2		STEP 5		STEP 6		STEP 7	
HOLE #	PLANE C	PLANE D	PLANE A	PLANE B	PLANE E	PLANE G	PLANE A	PLANE D	PLANE H	PLANE J
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
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STEP	PLANE	INITIAL UNBALANCE GR. INS.	ANGLE	FINAL UNBALANCE GR. INS.	ANGLE
1	C				
	D				
2	A				
	B				
3	S				
	T				
4	U				
	V				
5	E				
	G				
6	A				
	D				
7	H				
	J				
7A	P				
	J				

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4.0 ROTOR HIGH SPEED BALANCE ASSEMBLY - P/N 11394004.1 Front Bearing Cartridge Assembly

4.1.1 Obtain 2 bearings (P/N 1139188-2)
processed per procedure TMP-115
and per bearing inspection report,
together with supporting documentation.

4.1.2 Measure and record dimension (a) on
front cartridge 1139522-1 within $\pm .0001$
in. (see sketch).

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- 4.1.3 Record S/N of each bearing to be used in front cartridge assembly and its location.

Front Cartridge Assembly

Front Bearing S/N _____

Rear Bearing S/N _____

- 4.1.4 Record thickness b (see sketch in Step 4.1.2) of spacer 1139363-2 and spacer 1139363-3.

1139363-2 b_1 _____ in.

1139363-3 b_2 _____ in.

- 4.1.5 Assembly front bearing cartridge assembly with tooling as shown in sketch (Ref. Step 4.1.2) using spacer 1139363-3 (Ref. Step 4.1.4) and 28 springs (1137056-1) located in sequence shown in table 4.1.6. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

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- 4.1.6 Load assembly in tensile tester with
deflectometer to measure deflection (see
(Sketch in Step 4.1.2).

- 4.1.7 Measure load (f) vs deflection (δ) and
record on graph as shown in example curve.

EXAMPLE OF LOAD vs DEFLECTION CURVE

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- 4.1.8 Record load (f_1) and deflection (δ_1) from graph (Ref. Step 4.1.7) at point where spacer bottoms against bearings (see example curve in Step 4.1.7.

(f_1) _____ lb.

(δ_1) _____ in.

- 4.1.9 Measure with deflectometer and record axial movement (y_1) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_1) _____ in.

Record load used _____ lb.

- 4.1.10 Disassemble front bearing cartridge assembly.
- 4.1.11 Reassemble front bearing cartridge assembly with tooling as shown in sketch (Ref. Step 4.1.2) using spacer 1139363-3 (Ref. Step 4.1.4) and 28 springs (1137056-1) located in sequence shown on Table in Step 4.1.5. Ensure that high spot marks on inner race are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 4.1.12 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.1.2).
- 4.1.13 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in Step 4.1.7.

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- 4.1.14 Record load (f_2) and deflection (δ_2) from graph (Ref. Step 4.1.13) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_2) _____ lb.

(δ_2) _____ in.

- 4.1.15 Measure with deflectometer and record axial movement (y_2) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_2) _____ in.

Record load used _____ lb.

- 4.1.16 Disassemble front bearing cartridge assembly and package components to prevent damage.

- 4.1.17 Construct a set of curves of load (f) vs cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with 28 springs and the assumption that the number of springs/load/deflection relationships are linear.

(a) At (y_1) plot the load (f_1) for 28 springs.

(b) At (y_2) plot the load (f_2) for 28 springs.

(c) Connect these points with a straight line.

(d) Plot values of (f_1) and (f_2) at (y_1) and (y_2) respectively for other number of springs (n) based on the relationship.

$$(f_n) = (f_{28}) \left(\frac{(n)}{28} \right)$$

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(e) Connect these values with straight lines as shown in example curve.

NOTE: Curves must bracket point of $(f) = 600 \text{ lb.}$
and $(y) = .009 \text{ in.}$

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4.1.18 From curve (Ref. Step 4.1.17) select and record number of springs required to result in a load

(f) = 600 lb. at axial movement (y) = .009.

(n₁) _____ springs

4.1.19 Reassemble front bearing cartridge assembly with tooling as shown in Sketch (Ref. Step 4.1.2) using spacer 1139363-2 (Ref. Step 4.1.4) and (n₁) springs (Ref. Step 4.1.18) located in sequence shown on table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

4.1.20 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.1.2).

4.1.21 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (Ref. Step 4.1.7).

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- 4.1.22 Record load (f_3) and deflection (δ_3) from graph (Ref. Step 4.1.21) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_3) _____ lb.

(δ_3) _____ in.

- 4.1.23 Measure and record axial movement (y_3) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_3) _____ in.

Record load used _____ lb.

- 4.1.24 Disassemble front bearing cartridge assembly.

- 4.1.25 Reassemble front bearing cartridge assembly (with tooling as shown in sketch (Ref. Step 4.1.2) using spacer 1139363-3 (Ref. Step 4.1.4) and (n_1) springs (Ref. Step 4.1.18) located in sequence shown on table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 4.1.26 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.1.2).

- 4.1.27 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in Step 4.1.7.

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- 4.1.28 Record load (f_4) and deflection (δ_4) from graph (Ref. Step 4.1.27) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_4) _____ lb.

(δ_4) _____ in.

- 4.1.29 Measure and record axial movement (y_4) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_4) _____ in.

Record load used _____ lb.

- 4.1.30 Disassemble front bearing cartridge assembly and package components to prevent damage.

- 4.1.31 Construct a set of curves of load (f) vs cartridge axial move (y) on graph for various numbers of springs (n) based on the data obtained with (n_1) springs and the assumption that the number of springs/load/deflection relationships are linear.

(a) At (y_3) plot the load (f_3) for (n_1) springs.

(b) At (y_4) plot the load (f_4) for (n_1) springs.

(c) Connect these points with a straight line.

(d) Plot values of (f_3) and (f_4) at (y_3) and (y_4) respectively for $((n_1) - 1)$ springs and $((n_1) + 1)$ springs based on the relationship.

$$(f_n) = (f_{n1}) \left(\frac{(n)}{(n_1)} \right)$$

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(e) Connect these values with straight lines
as shown in example curve in Step 4.1.17.

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- 4.1.32 If the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the $(n_1 - 1)$ line and the $(n_1 + 1)$ line continue with step 4.1.33. If it does not, repeat steps 4.1.17 through 4.1.32 until the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the lines for one less or more springs then is being used. Record all values and plot all graphs each time.

- 4.1.33 Record number of springs to be used in front cartridge.
_____ springs (1137056-1)

- 4.1.34 Calculate and record required spacer thickness

$$(b_3) = (b_2) + \frac{(.009 - (y_4)) ((b_1) - (b_2))}{(y_3) - (y_4)}$$

(b_2) and (y_4) are recorded in steps 4.1.4 and 4.1.29 respectively).

(b_3) _____ in.

- 4.1.35 Grind spacer 1139363-1 to (b_3) dimension per sketch and mark as indicated.

Record actual (b_3) _____ in.

Record serial number _____.

REMOVE ALL BURRS AND SHARP EDGES
EQUIVALENT TO .005 - .015 R.

MARK PER ASD5215C WITH "MOD" FOLLOWING
EXISTING PART NUMBER AND ACTUAL (b_3)

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4.1.36 Reassemble front bearing cartridge assembly with tooling as shown in sketch (Ref. Step 4.1.2) using spacer ground from 1139363-1 in Step 4.1.35 and number of springs recorded in Step 4.1.33 located in sequence shown on table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

4.1.37 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.1.2).

4.1.38 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (Ref. Step 4.1.7).

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- 4.1.39 Record load (f_5) and deflection (δ_5) from graph (Ref. Step 4.1.38) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_5) _____ lb.

(δ_5) _____ in.

NOTE: (f_5) should be within 600 ± 25 lb.

- 4.1.40 Measure and record axial movement (y_5) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_5) _____ in.

Record load used _____ lb.

NOTE: (y_5) should be within $.0090 \pm .0001$ in.

- 4.1.41 Disassemble front bearing cartridge assembly and package to prevent damage. Assure that all parts are adequately identified to the front bearing cartridge assembly.

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4.2 Aft Bearing Cartridge Assembly

4.2.1 Obtain 2 bearings (P/N 1139188-2) processed per procedure TMP-115 and per bearing inspection report, together with supporting documentation.

4.2.2 Measure and record dimensions (c) on aft cartridge 1139521-1 within $\pm .0001$ in. (see sketch).

(c) _____ in.

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- 4.2.3 Record S/N of each bearing to be used in aft cartridge assembly and its location.

Aft Cartridge Assembly

Front Bearing S/N _____

Rear Bearing S/N _____

- 4.2.4 Assemble aft bearing cartridge assembly with tooling as shown in sketch (Ref. Step 4.2.2) using spacer 1139363-2 (Ref. Step 4.1.4) and 28 springs (1137056-1) located in sequence shown in table (Ref. Step 4.1.5). Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 4.2.5 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.2.2).

- 4.2.6 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (Ref. Step 4.1.7).

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- 4.2.7 Record load (f_6) and deflection (δ_6) from graph (Ref. Step 4.1.7) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_6) _____ lb.

(δ_6) _____ in.

- 4.2.8 Measure with deflectometer and record axial movement (y_6) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_6) _____ in.

Record load used _____ lb.

- 4.2.9 Disassemble aft bearing cartridge assembly.

- 4.2.10 Reassemble aft bearing cartridge assembly with tooling as shown in sketch (Ref. Step 4.2.2) using spacer 1139363-3 (Ref. Step 4.1.4) and 28 springs (1137056-1) located in sequence shown on table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 4.2.11 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.2.2).

- 4.2.12 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in Step 4.1.7.

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- 4.2.13 Record load (f_7) and deflection (δ_7) from graph (Ref. Step 4.1.13) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_7) _____ lb.

(δ_7) _____ in.

- 4.2.14 Measure with deflectometer and record axial movement (y_7) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

y_7 _____ in.

Record load used _____ lb.

- 4.2.15 Disassemble aft bearing cartridge assembly and package components to prevent damage.

- 4.2.16 Construct a set of curves of load (f) vs cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with 28 springs and the assumption that the number of springs/load/deflection relationships are linear.

(a) At (y_6) plot the load (f_6) for 28 springs.

(b) At (y_7) plot the load (f_7) for 28 springs.

(c) Connect these points with a straight line.

(d) Plot values of (f_6) and (f_7) at (y_6) and

(y_7) respectively for other number of springs

(n) based on the relationship.

$$(f_n) = (f_{28}) \left(\frac{(n)}{28} \right)$$

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(e) Connect these values with straight lines as shown in example curve.

NOTE: Curves must bracket point of $\textcircled{f} = 600 \text{ lb.}$
and $\textcircled{y} = .009 \text{ in.}$

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4.2.17 From Curve (Ref. Step 4.2.16) select and record number of springs required to result in a load $(f) = 600$ lb. at axial movement $(y) = .009$.

(n_2) _____ springs.

4.2.18 Reassemble aft bearing cartridge assembly with tooling as shown in sketch (Ref. Step 4.2.2) using spacer 1139363-2 (Ref. Step 4.14) and (n_2) springs (Ref. Step 4.2.17) located in sequence shown on Table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

4.2.19 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.2.2).

4.2.20 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (Ref. Step 4.1.7).

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- 4.2.21 Record load (f_8) and deflection (δ_8) from graph (Ref. Step 4.2.20) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

(f_8) _____ lb.

(δ_8) _____ in.

- 4.2.22 Measure and record axial movement (y_8) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_8) _____ in.

Record load used _____ lb.

- 4.2.23 Disassemble aft bearing cartridge assembly.

- 4.2.24 Reassemble aft bearing cartridge assembly with tooling as shown in Sketch (Ref. Step 4.2.2) using spacer 1139363-3 (Ref. Step 4.14) and (n_2) springs (Ref. Step 4.2.17) located in sequence shown on table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 4.2.25 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.2.2).

- 4.2.26 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in Step 4.1.7.

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- 4.2.27 Record load (f_9) and deflection (δ_9) from graph (Ref. Step 4.2.26) at point where spacer bottoms against bearings (see example curve in Step 4.1.17)

(f_9) _____ lb.

(δ_9) _____ in.

- 4.2.28 Measure and record axial movement (y_9) (within $\pm .0001$ in.) on cartridge when moved manually at load indicated on example curve in Step 4.1.7.

(y_9) _____ in.

Record load used _____ lb.

- 4.2.29 Disassemble aft bearing cartridge assembly and package components to prevent damage.

- 4.2.30 Construct a set of curves of load (f) vs cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with (n_2) springs and the assumption that the number of springs/load/deflection relationships are linear.

- At (y_8) plot the load (f_8) for (n_2) springs.
- At (y_9) plot the load (f_9) for (n_2) springs.
- Connect these points with a straight line.
- Plot values of (f_8) and (f_9) at (y_8) and (y_9) respectively for $(n_2 - 1)$ springs and $(n_2 + 1)$ springs based on the relationship.

$$(f_n) = (f_{n_2}) \left(\frac{n}{n_2} \right)$$

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- (e) Connect these values with straight lines
as shown in example curve in Step 4.1.17.

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- 4.2.31 If the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the $((n_2) - 1)$ line and the $((n_2) + 1)$ line continue with Step 4.2.32. If it does not, repeat Steps 4.2.16 through 4.2.32 until the point $(f) = 600$ lb and $(y) = .009$ in. lies between the lines for one less or one more spring than is being used.

Record all values and plot all graphs each time.

- 4.2.32 Record number of springs to be used in aft cartridge.

_____ Springs (1137056-1)

- 4.2.33 Calculate and record required spacer thickness

$$(b_4) = (b_2) + \frac{(.009 - (y_9)) ((b_1) - (b_2))}{(y_8) - (y_9)} ((b_2))$$

and (y_9) are recorded in Step 4.1.4 and 4.2.28 respectively).

(b_4) _____ in.

- 4.2.34 Grind spacer (1139363-1) to (b_4) dimension per sketch and mark as indicated

Record actual (b_4) _____ in.

Record S/N _____

REMOVE ALL BURRS AND SHARP
EDGES EQUIVALENT TO .005-.015 R.

MARK PER ASD 5215 C WITH "MOD"

FOLLOWING EXISTING P/N AND ACTUAL (b_4)

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4.2.35 Reassemble aft bearing cartridge assembly with tooling as shown in Sketch (Ref. Step 4.2.2) using spacer ground from 1139363-1 in Step 4.2.34 and number of springs recorded in Step 4.2.32 located in sequence shown on table in Step 4.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

4.2.36 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in Step 4.2.2).

4.2.37 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (Ref. Step 4.1.7).

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- 4.2.38 Record load f_{10} and deflection δ_{10} from graph (Ref. Step 4.2.37) at point where spacer bottoms against bearings (see example curve in Step 4.1.7).

f_{10} _____ lb. δ_{10} _____ in.NOTE: f_{10} should be within 600 ± 25 lb.

- 4.2.39 Measure and record axial movement y_{10} (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in Step 4.1.7.

y_{10} _____ in.

Record load used _____ lb.

NOTE: y_{10} should be within $.0090 \pm .0001$ in.

- 4.2.40 Disassemble aft bearing cartridge assembly and package to prevent damage. Assure that all parts are adequately identified to the aft bearing cartridge assembly.

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4.3 Assembly (beginning at Step 1 on 1139400)

- 4.3.1 Set up impeller, 2nd stage 1139470-1 (which includes tie bolt and inserts already installed) vertically with front end down and cool aft end by pouring LN_2 down hole in impeller shaft.

- 4.3.2 Install aft bearing cartridge assembly onto impeller, 2nd stage, using T1050225. Ensure that match marks on spacers and high spot marks on bearing inner races are aligned with $\theta = 0^\circ$ (#1 balance screw hole) on impeller.

- 4.3.3 Set up impeller, 2nd stage vertically with aft end down and cool fron end by pouring LN_2 down hole in impeller shaft.

- 4.3.4 Install fron bearing cartridge assembly onto impeller, 2nd stage, using T1050225. Ensure that match marks on spacers and high spot marks on bearing inner race are aligned with $\theta = 0^\circ$. (#1 balance screw hole).

- 4.3.5 Clamp impeller, 2nd stage in cradle assembly T1050213 and warm both ends of tie bolt with heat gun to remove moisture. Do not exceed $250^\circ F$.

- 4.3.6 Cool adaptor 1139525-1 in LN_2 and install on front end of impeller, 2nd stage. Ensure that match marks on adaptor is aligned with $\theta = 0^\circ$ on impeller.

- 4.3.7 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assembly to $500^\circ F$ in furnace and install on adaptor 1139525-1. When parts return to room temperature, remove tool.

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- 4.3.8 Install lockwasher 1139385-1 and nut 1139384-1 onto front end of tie bolt finger tight. Do not bend lockwasher tabs.
- 4.3.9 Cool adaptor 1139526-1 in LN₂ and install on aft end of impeller, 2nd stage.
- 4.3.10 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assembly to 500°F in furnace and install on adaptor 1139526-1. When parts return to room temperature, remove tool.
- 4.3.11 Install lockwasher 1139387-1 and nut 1139386-1 onto aft end of tie bolt finger tight. Do not bend lockwasher tabs.
- 4.3.12 Hang cylinder T1050263, Item 2, from crane in a horizontal position.
- 4.3.13 Insert wrench T1050260-1 into thrust sleeve T1050259-1 and assemble thrust sleeve to cylinder.
- 4.3.14 Hook up hand pump T1050263, Item 15, and associated equipment to cylinder.
- 4.3.15 Fill system with oil T1050263, Item 23, and bleed system of air.
- 4.3.16 Insert free end of thrust sleeve over adaptor 1139525-1. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely against adaptor.
- 4.3.17 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.

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4.3.18 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

4.3.19 Using hand pump, extend cylinder ram to take up clearance T1050258-1. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

4.3.20 Using hand pump, stretch tie bolt until pressure gage reads 3000 psi.

4.3.21 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand).

4.3.22 Record dial indicator reading, $E = \underline{\hspace{2cm}}$ in.

4.3.23 Compute and record, $F - E + D + .030 = \underline{\hspace{2cm}}$ in.

4.3.24 Using hand pump, stretch bolt until indicator reading is F. Record actual $F = \underline{\hspace{2cm}}$ in.

Record cylinder pressure = $\underline{\hspace{2cm}}$ psi.

NOTE: DO NOT EXCEED 3700 psi.

4.3.25 Turn nut 1139384-1 up by hand using wrench T1050260-1.

4.3.26 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand).

4.3.27 Record dial indicator reading, $G = \underline{\hspace{2cm}}$ in.

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4.3.28 Compute and record, $H = G - E =$ _____ in.

4.3.29 If $H = .030 \pm .001$, go to Step 4.3.37. If not, continue with Step 4.3.30.

4.3.30 Compute and record $.030 - H =$ _____ in.

4.3.31 Using hand pump, stretch bolt until indicator reading is $F_1 = F + .030 - H =$ _____ in. (Nut may have to be loosened).

Record actual $G_1 =$ _____ in.

Record cylinder pressure _____ psi.

NOTE: DO NOT EXCEED 3700 Psi.

4.3.32 Turn nut up by hand using wrench.

4.3.33 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 4.3.26.

4.3.34 Record indicator reading, $G_1 =$ _____ in.

4.3.35 Compute and record $H_1 = G_1 - F =$ _____ in.

4.3.36 If $H_1 = .030 \pm .001$, go to Step 4.3.37. If not, repeat steps 4.3.30 through 4.3.36 until it is. Record all values each time.

4.3.37 Remove dial indicator and unscrew measuring rod T1050261-1.

4.3.38 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Bend lockwasher tabs.

4.3.39 Insert free end of thrust sleeve T1050259-1 over adapter 1139526-1.

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4.3.40 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.

4.3.41 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

4.3.42 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor, and aligned freely against adaptor.

4.3.43 Using hand pump, stretch tie bolt until pressure gage reads 2750 psi.

4.3.44 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand).

4.3.45 Record dial indicator reading, $J = \underline{\hspace{2cm}}$ in.

4.3.46 Compute and record $K = J + C + .018 = \underline{\hspace{2cm}}$ in.

4.3.47 Using hand pump, stretch bolt until indicator reading is K. Record actual $K = \underline{\hspace{2cm}}$ in.

Record cylinder pressure = $\underline{\hspace{2cm}}$ psi.

NOTE: DO NOT EXCEED 3700 psi.

4.3.48 Turn nut 1139386-1 up by hand using wrench T1050260-1.

4.3.49 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand).

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4.3.50 Record dial indicator reading, $L =$ _____ in. 4.3.51 Compute and record $M = L - K =$ _____ in. 4.3.52 If $M = .018 \pm .001$, go to Step 4.3.59. If not, continue with Step 4.3.53. 4.3.53 Compute and record $.018 - N =$ _____ in. 4.3.54 Using hand pump, stretch bolt until indicator reading is $K_1 = K + .018 - N =$ _____ in.
(Nut may have to be loosened.) Record actual $L_1 =$ _____ in.

Record Cylinder pressure _____ psi

NOTE: DO NOT EXCEED 3700 PSI.

4.3.55 Turn nut up by hand using wrench.

4.3.56 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 4.3.49.

4.3.57 Record dial indicator reading $L_1 =$ _____ in. 4.3.58 Compute and record $M_1 = L_1 - J =$ _____ in. If $M_1 = .018 \pm .001$ go to Step 4.3.59. If not repeat Steps 4.3.53 through 4.3.58 until it is.
Record all values each time.

4.3.59 Remove dial indicator and unscrew measuring rod T-1050261-1.

4.3.60 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Bend lockwasher tabs.

4.3.61 Remove impeller assembly from cradle.

4.4 Disassembly of Step 1

4.4.1 Clamp impeller assembly in cradle assembly T1050213. Set up bolt stretcher at aft end of impeller, 2nd stage.

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4.4.2 Insert free end of thrust sleeve T1050259-1 over adaptor 1139526-1.

4.4.3 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.

4.4.4 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.

4.4.5 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

4.4.6 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 4.3.47 or 4.3.54, whichever is higher.
NOTE: DO NOT EXCEED 3700 PSI.

4.4.7 Back off nut 1139386-1 by using wrench T1050260-1.

4.4.8 Remove dial indicator and unscrew measuring rod T1050261-1.

4.4.9 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.

4.4.10 Set up bolt stretcher on crane at front end of second stage impeller.

4.4.11 Insert free end of thrust sleeve T1050259-1 over adaptor 1139525-1.

4.4.12 Thread pull sleeve T1050258-1 into end of tiebolt finger tight and then back it out 1 turn.

4.4.13 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.

4.4.14 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

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- 4.4.15 Using hand pump stretch tie bolt until pressure is at cylinder pressure in step 4.3.22 or 4.3.29 whichever is higher.

NOTE: DO NOT EXCEED 3700 PSI.

- 4.4.16 Back off nut 1139384-1 by using wrench T1050260-1.
- 4.4.17 Remove dial indicator and unscrew measuring rod T1050261-1.
- 4.4.18 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
- 4.4.19 Remove nut 1139384-1 and lockwasher 1139385-1.
- 4.4.20 Assemble puller T1050239-1 on cap retaining 1139430-1 and remove cap.
- 4.4.21 Assemble puller T1050244 Step 2 onto rotor and remove adapter 1139525-1.

4.5 Assembly of Step 2

- 4.5.1 Install shim 1139407-1 onto front end of impeller 2nd stage.
- 4.5.2 Cool aft end of pump rotor, subassembly 1139441-5 in LN_2 and warm front end of impeller, 2nd stage to 250°F with heat gun (do not heat tie bolt) and install pump rotor into impeller, 2nd stage.
- 4.5.3 Warm ends of tie bolt with heat gun to remove moisture. Do not exceed 250°F.
- 4.5.4 Install cap, retaining 1139430-1 onto tool T1050249-1 and heat assy to 500°F in furnace and install onto pump rotor, subassembly. When parts return to room temperature remove tool.

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- 4.5.5 Install lockwasher 1139385-1 and nut 1139384-1 finger tight using wrench T1050254-1 onto front end of tiebolt. Do not bend lockwasher tabs.
- 4.5.6 Set up bolt stretcher at front end of inducer.
- 4.5.7 Insert free end of thrust sleeve into inducer. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely inside inducer.
- 4.5.8 Thread pull sleeve T1050258-1 onto end of tiebolt finger tight and then back it out 1 turn.
- 4.5.9 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.
- 4.5.10 Using hand pump, extend cylinder ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against first stage impeller and aligned freely inside inducer.
- 4.5.11 Using hand pump, stretch tiebolt until pressure gage reads 3000psi.
- 4.5.12 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.
- 4.5.13 Record dial indicator reading, $E = \underline{\hspace{2cm}}$ in.
- 4.5.14 Compute and record, $F = E + D + .030 = \underline{\hspace{2cm}}$ in.
- 4.5.15 Using hand pump, stretch bolt until indicator reading is F .
Record actual $F = \underline{\hspace{2cm}}$ in.
Record cylinder pressure $\underline{\hspace{2cm}}$ psi.
NOTE: DO NOT EXCEED 3700 PSI.

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4.5.16 Turn nut 1139384-1 up by hand using wrench T1050260-1.

4.5.17 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)

4.5.18 Record dial indicator reading, $G = \underline{\hspace{1cm}}$ in.

4.5.19 Compute and record, $H = G - E = \underline{\hspace{1cm}}$ in.

4.5.20 If $H = .030 \pm .001$ go to step 4.5.28. If not continue with Step 4.5.21.

4.5.21 Compute and record $.030 - H = \underline{\hspace{1cm}}$ in.

4.5.22 Using hand pump stretch bolt until indicator reading is $F_1 = F + .030 - H = \underline{\hspace{1cm}}$ in. (Nut may have to be loosened.)

Record actual $G_1 = \underline{\hspace{1cm}}$ in.

Record cylinder pressure $\underline{\hspace{1cm}}$ psi.

NOTE: DO NOT EXCEED 3700 PSI.

4.5.23 Turn nut up by hand using wrench.

4.5.24 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 4.5.17.

4.5.25 Record indicator reading, $G_1 = \underline{\hspace{1cm}}$ in.

4.5.26 Compute and record $H_1 = G_1 - F = \underline{\hspace{1cm}}$ in.

4.5.27 If $H_1 = .030 \pm .001$ go to step 4.5.28. If not, repeat steps 4.5.21 through 4.5.27 until it is. Record all values each time.

4.5.28 Remove dial indicator and unscrew measuring rod T1050261-1.

4.5.29 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Bend lockwasher tabs.

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4.5.30 Cool spinner 1139383-1 in LN₂ and install on inducer (Pump Rotor Subassy 1139441).

4.5.31 When parts return to room temperature install washer 1139463-1 and bolt 1139464-1. Torque bolt to drawing requirements. Bend lockwasher tabs.

4.5.32 Insert free end of thrust sleeve T1050259-1 over adaptor 1139526-1.

4.5.33 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.

4.5.34 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

4.5.35 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

4.5.36 Using hand pump stretch tie bolt until pressure gage reads 2750 psi.

4.5.37 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)

4.5.38 Record dial indicator reading, J = _____ in.

4.5.39 Compute and record K - J + C + .018 = _____ in.

4.5.40 Using hand pump stretch bolt until indicator reading is K. Record actual K = _____ in.
Record cylinder pressure = _____ psi.

NOTE: DO NOT EXCEED 3700 PSI.

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4.5.41 Turn nut 1139386-1 up by hand using wrench T1050260-1.

4.5.42 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.).

4.5.43 Record dial indicator reading, $L = \underline{\hspace{1cm}}$ in.

4.5.44 Compute and record $M = L - K - \underline{\hspace{1cm}}$ in.

4.5.45 If $M = .018 \pm .001$ go to Step 4.5.52. If not, continue with Step 4.5.46.

4.5.46 Compute and record $.018 - N = \underline{\hspace{1cm}}$ in.

4.5.47 Using hand pump stretch bolt until indicator reading is $K_1 = K + .018 - N = \underline{\hspace{1cm}}$ in. (Nut may have to be loosened.)

Record actual $L_1 = \underline{\hspace{1cm}}$ in.

Record cylinder pressure psi.

NOTE: DO NOT EXCEED 3700 PSI.

4.5.48 Turn nut up by hand using wrench.

4.5.49 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 4.5.42.

4.5.50 Record dial indicator reading, $L_1 = \underline{\hspace{1cm}}$ in.

4.5.51 Compute and record $M_1 = L_1 - J = \underline{\hspace{1cm}}$ in.

If $M_1 = .018 \pm .001$ go to step 4.5.52. If not, repeat Steps 4.5.42 through 4.5.51 until it is. Record all values each time.

4.5.52 Remove dial indicator and unscrew measuring rod T1050261-1.

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4.5.53 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher. Bend lockwasher tabs.

4.5.54 Remove impeller assembly from cradle.

4.6 Disassembly of Step 2

4.6.1 Clamp impeller assembly in cradle assembly T1050213.
Set up bolt stretcher at aft end of impeller, 2nd
stage.

4.6.2 Insert free end of thrust sleeve T1050259-1 over
adaptor 1139526-1.

4.6.3 Install spacer T1050262-1 into pull sleeve T1050258
and thread onto end of tie bolt finger tight and
then back it out 1 turn.

4.6.4 Thread measuring rod T1050261-1 into end of tie bolt
and set up dial indicator.

4.6.5 Using hand pump extend ram to take up clearance
between ram and collar on pull sleeve. Ensure that
thrust sleeve is seated squarely against adaptor and
aligned freely against adaptor.

4.6.6 Using hand pump stretch tie bolt until pressure at
cylinder pressure in Step 4.3.45 or 4.3.52 whichever
is higher.

4.6.7 Back off nut 1139386-1 by using wrench T1050260-1.

4.6.8 Remove dial indicator and unscrew measuring rod
T1050261-1.

4.6.9 Unscrew pull sleeve T1050258-1 and remove bolt
stretcher.

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4.6.10 Remove nut 1139386 and lockwasher 1139387.

4.6.11 Assemble puller T1050265-1 on cap retaining 1139430-1 and remove cap.

4.6.12 Install puller T1050244 Step 1 onto rotor and remove adaptor 1139526-1.

4.6.13 Remove impeller assembly from cradle.

4.7 Assembly of Step 3

4.7.1 Clamp impeller assembly in cradle assembly T1050213.

4.7.2 Cool front end of turbine rotor subassembly 1139442 in LN₂ and warm rear end of impeller, 2nd stage, to 250°F with heat gun (do not heat tie bolt) and install turbine rotor into impeller, 2nd stage.

4.7.3 Warm end of tie bolt with heat gun to remove moisture. Do not exceed 250°F.

4.7.4 Install lockwasher 1139387-1 and nut 1139386-1 finger tight. Do not bend lockwasher tabs.

4.7.5 Set up bolt stretcher on crane at turbine location.

4.7.6 Insert free end of thrust sleeve T1050259-1 into turbine, 2nd stage.

4.7.7 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.

4.7.8 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

4.7.9 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against turbine, 1st stage and aligned freely inside turbine, 2nd stage.

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4.7.10 Using hand pump stretch tie bolt until pressure gage reads 2750 psi.

4.7.11 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)

4.7.12 Record dial indicator reading, $J = \underline{\hspace{2cm}}$ in.

4.7.13 Compute and record $K = J + C + .018 = \underline{\hspace{2cm}}$ in.

4.7.14 Using hand pump stretch bolt until indicator reading is K. Record Actual $K = \underline{\hspace{2cm}}$ in.

Record cylinder pressure = $\underline{\hspace{2cm}}$ psi.

NOTE: DO NOT EXCEED 3700 PSI.

4.7.15 Turn nut 1139386-1 up by hand using wrench T1050260-1.

4.7.16 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)

4.7.17 Record dial indicator reading, $L = \underline{\hspace{2cm}}$ in.

4.7.18 Compute and record $M = L - K = \underline{\hspace{2cm}}$ in.

4.7.19 If $M = .018 \pm .001$ go to Step 4.7.26. If not, continue with Step 4.7.20.

4.7.20 Compute and record $.018 - N = \underline{\hspace{2cm}}$ in.

4.7.21 Using hand pump stretch bolt until indicator reading is $K_1 = K + .018 - N = \underline{\hspace{2cm}}$ in. (Nut may have to be loosened.)

Record actual $L_1 = \underline{\hspace{2cm}}$ in.

Record cylinder pressure $\underline{\hspace{2cm}}$ psi.

NOTE: DO NOT EXCEED 3700 PSI.

4.7.22 Turn nut up by hand using wrench.

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4.7.23 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 4.7.16.

4.7.24 Record dial indicator reading $L_1 =$ _____ in.

4.7.25 Compute and record $M_1 = L_1 - J =$ _____ in.
If $M_1 = .018 \pm .001$ go to Step 4.7.26. If not, repeat Steps 4.7.19 through 4.7.25 until it is. Record all values each time.

4.7.26 Remove dial indicator and unscrew measuring rod T1050261-1.

4.7.27 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Bend lockwasher tabs.

4.7.28 Remove rotor assembly from cradle.

4.8 Disassembly of Step 3

4.8.1 Clamp rotor assembly in cradle assembly T1050213 and set up bolt stretcher on crane at turbine location.

4.8.2 Insert free end of thrust sleeve T1050259-1 into turbine, 2nd stage.

4.8.3 Install spacer T1050262-1 into pull sleeve T1050258-1 and thread onto end tie bolt finger tight and then back it out 1 turn.

4.8.4 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

4.8.5 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against turbine, 1st stage and aligned freely inside turbine 2nd stage.

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- 4.8.6 Using hand pump stretch tie bolt until pressure is at cylinder pressure in Step 4.7.14 or 4.7.21 whichever is higher.

NOTE: DO NOT EXCEED 3700 PSI.

- 4.8.7 Back off nut 1139386-1 by using wrench T1050260-1.
- 4.8.8 Remove dial indicator and unscrew measuring rod T1050261-1.
- 4.8.9 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
- 4.8.10 Remove nut 1139386-1 and lockwasher 1139387-1.
- 4.8.11 Assemble puller T1050265-1 on cap retaining 1139430-1 and remove cap.
- 4.8.12 Assemble puller T1050231-2 on turbine, 2nd stage and remove turbine rotor, subassembly 1139442.
- 4.8.13 Unscrew bolt 1139464-1 and remove washer 1139463-1 from spinner.
- 4.8.14 Install puller T1050242-1 onto spinner and remove spinner from inducer.
- 4.8.15 Set up bolt stretcher on crane at pump location.
- 4.8.16 Insert free end of thrust sleeve T1050259-1 into inducer.
- 4.8.17 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back it out 1 turn.
- 4.8.18 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

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- 4.8.19 Using hand pump extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against impeller, 1st stage and aligned freely inside inducer.
- 4.8.20 Using hand pump stretch tie bolt until pressure is at cylinder pressure in Step 4.5.15 or 4.5.22 whichever is higher.
NOTE: DO NOT EXCEED 3700 PSI.
- 4.8.21 Back off nut 1139384-1 by using wrench T1050260-1.
- 4.8.22 Remove dial indicator and unscrew measuring rod T1050261-1.
- 4.8.23 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
- 4.8.24 Remove nut 1139384-1 and lockwasher 1139385-1.
- 4.8.25 Assemble puller T1050239-1 on cap retaining 1139430-1 and remove cap.
- 4.8.26 Assemble clamping tool T1050208-1 between tie bolt and impeller 2nd stage.
- 4.8.27 Assemble puller T1050232 Step 1 on inducer and remove pump rotor, subassembly 1139441.
- 4.8.28 Remove shim 1139407-1.
- 4.8.29 Remove impeller, 2nd stage from cradle.
- 4.8.30 Install impeller, 2nd stage, in arbor press using tool T1050225 to press off aft bearing cartridge assembly.
- 4.8.31 Reverse impeller in arbor press and using tool T1050225 press off front bearing cartridge assembly.

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4.8.32 Disassemble tie bolt stretcher T1050263 and rebox.

4.8.33 Complete tables of balance screw weight and unbalance
per plane.

4.8.34 Do not remove tie bolt.

4.8.35 Do not disassemble turbine rotor subassembly
1139442 and pump rotor subassembly 1139441.

[illegible]

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STEP	PLANE	INITIAL UNBALANCE GR. INS.	ANGLE	FINAL UNBALANCE GR. INS.	ANGLE
1	C				
	D				
2	A				
	B				
3	S				
	T				
4	U				
	V				
5	E				
	G				
6	A				
	D				
7	H				
	J				
7A	P				
	J				

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5.0 TURBOPUMP ASSEMBLY, PART NUMBER 11393505.1 FRONT BEARING CARTRIDGE ASSEMBLY

- 5.1.1 Obtain 2 bearings (P/N 1139792-2) processed per procedures TMP - 115 and per bearing inspection report, together with supporting documentation.

- 5.1.2 Measure and record dimension (a) on front cartridge 1139401-1 within $\pm .0001$ in. (see sketch)

(a) _____ in.

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- 5.1.3 Record S/N of each bearing to be used in front cartridge assembly and its location.

Front Cartridge Assembly

Front Bearing S/N _____

Rear Bearing S/N _____

- 5.1.4 Record thickness (b) (See sketch in step 5.1.2 of spacer 1139363-3 and spacer 1139363-4)

1139363-3 (b₁) _____ in.

1139363-4 (b₂) _____ in.

- 5.1.5 Assemble front bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer 1139363-2 and 36 springs (1137056-1) located in sequence shown in table and load to 600 pounds in tensile tester. Ensure that high spot marks on inner races are aligned and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 5.1.6 Put front bearing cartridge assembly and tooling into cres flask of LN₂ and check clearance between bearing and cartridge by lifting cartridge with piano wires.

- 5.1.7 When parts return to room temperature, disassemble front bearing cartridge assembly.

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5.1.8 Reassemble front bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer 1139363-3 (ref. step 5.1.4) and 28 springs (1137056-1) located in sequence shown in table. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.1.9 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.1.2).

5.1.10 Measure load (f) vs. deflection (δ) and record on graph as shown in example curve.

EXAMPLE OF LOAD vs. DEFLECTION CURVE

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- 5.1.11 Record load (f_1) and deflection (δ_1) from graph (ref. step 5.1.10) at point where spacer bottoms against bearings (see example curve in step 5.1.10).

(f_1) _____ lb.

(δ_1) _____ in.

- 5.1.12 Measure with deflectometer and record axial movement (y_1) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_1) _____ in.

Record load used _____ lb.

- 5.1.13 Disassemble front bearing cartridge assembly

- 5.1.14 Reassemble front bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer 1139363-4 (ref. step 5.1.4) and 28 springs (1137056-1) located in sequence shown in table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 5.1.15 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.1.2)

- 5.1.16 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in step 5.1.10.

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- 5.1.17 Record load (f_2) and deflection (δ_2) from graph (ref. step 5.1.6) at point where spacer bottoms against bearings (see sample curve in step 5.1.10)

(f_2) _____ lb.

(δ_2) _____ in.

- 5.1.18 Measure with deflectometer and record axial movement (y_2) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_2) _____ in.

Record load used _____ lb.

- 5.1.19 Disassemble front bearing cartridge assembly and package components to prevent damage.

- 5.1.20 Construct a set of curves of load (f) versus cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with 28 springs and the assumption that the number of springs / load / deflection relationships are linear.

(a) At (y_1) plot the load (f_1) for 28 springs

(b) At (y_2) plot the load (f_2) for 28 springs

(c) Connect these points with a straight line.

(d) Plot values of (f_1) and (f_2) at (y_1) and (y_2) respectively for other number of springs n based on the relationship.

$$(f_n) = (f_{28}) \left(\frac{(n)}{28} \right)$$

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(e) Connect these values with straight lines as shown
in example curve.

NOTE: Curves must bracket point of $(f) = 600$ lb.
and $(y) = .009$ in.

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5.1.21 From curve (ref. step 5.1.20) select and record number of springs required to result in a load $(f) = 600$ lb. at axial movement

$(y) = .009$.

(n_1) _____ springs

5.1.22 Reassemble front bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer 1139363-3 (ref. step 5.1.4) and (n_1) springs (ref. step 5.1.21) located in sequence shown on table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.1.23 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.1.2)

5.1.24 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (ref. step 5.1.10)

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- 5.1.25 Record load (f_3) and deflection (δ_3) from graph (ref. step 5.1.24) at point where spacer bottoms against bearings (see example curve in step 5.1.10).

(f_3) _____ lb.

(δ_3) _____ in.

- 5.1.26 Measure and record axial movement (y_3) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_3) _____ in.

Record load used _____ lb.

- 5.1.27 Disassemble front bearing cartridge assembly.

- 5.1.28 Reassemble front bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer 1139363-4 (ref. step 5.1.4) and (n_1) springs (ref. step 5.1.21) located in sequence shown on table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 5.1.29 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.1.2).

- 5.1.30 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in step 5.1.10.

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- 5.1.31 Record load (f_4) and deflection (δ_4) from graph (ref. step 5.1.30) at point where spacer bottoms against bearings (see sample curve in step 5.1.10).

(f_4) _____ lb.
 (δ_4) _____ in.

- 5.1.32 Measure and record axial movement (y_4) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10

(y_4) _____ IN.
 Record load used _____ lb.

- 5.1.33 Disassemble front bearing cartridge assembly and package components to prevent damage.

- 5.1.34 Construct a set of curves of load (f) versus cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with (n_1) springs and the assumption that the number of springs / load / deflection relationships are linear.

- At (y_3) plot the load (f_3) for (n_1) springs.
- At (y_4) plot the load (f_4) for (n_1) springs.
- Connect these points with a straight line.
- Plot values of (f_3) and (f_4) at (y_3) and (y_4) respectively for $(n_1 - 1)$ springs and $(n_1 + 1)$ springs based on the relationship.

$$(f_n) = (f_{n_1}) \left(\frac{n}{n_1} \right)$$

- Connect these values with straight lines as shown in example curve in step 5.1.20.

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- 5.1.35 If the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the $(n_1 - 1)$ line and the $(n_1 + 1)$ line continue with step 5.1.36. If it does not, repeat steps 5.1.20 through 5.1.35 until the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the lines for one less or one more spring then is being used. Record all values and plot all graphs each time.

- 5.1.36 Record number of springs to be used in front cartridge
_____ Springs (1137056-1)

- 5.1.37 Calculate and record required spacer thickness

$$b_3 = b_2 + \frac{(.009 - y_4)(b_1 - b_2)}{y_3 - y_4}$$

b_3 _____ in.

(b_2) and (y_4) are recorded in step 5.1.4 and 5.1.32 respectively)

- 5.1.38 Grind spacer 1139363-1 to (b_3) dimension per sketch and mark as indicated.

Record actual b_3 _____ in.

Record serial number _____.

REMOVE ALL BURRS AND SHARP EDGES EQUIVALENT TO .005 - .015 R.

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5.1.39 Reassemble front bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer ground from 1139363-1 in step 5.1.38 and number of springs recorded in step 5.1.30 located in sequence shown on table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.1.40 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.1.2).

5.1.41 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (ref. step 5.1.10).

5.1.42 Record load (f_5) and deflection (δ_5) from graph (ref. step 5.1.41) at point where spacer bottoms against bearings (see sample curve in step 5.1.10).

(f_5) _____ lb.

(δ_5) _____ in.

NOTE: (f_5) should be within 600 ± 25 lb.

5.1.43 Measure and record axial movement (y_5) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_5) _____ in.

Record load used _____ lb.

NOTE: (y_5) should be within $.0090 \pm .0001$ in.

5.1.44 Disassemble front bearing cartridge assembly and package to prevent damage. Assure that all parts are adequately identified to the front bearing cartridge assembly.

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5.2 AFT BEARING CARTRIDGE ASSEMBLY

5.2.1 Obtain 2 bearings (P/N 1139792-2) processed per procedures TMP - 115 and per bearing inspection report, together with supporting documentation.

5.2.2 Measure and record dimension (c) and (d) on rear cartridge 1139402-1 within $\pm .0001$ in. (see sketch)

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- 5.2.3 Record S/N of each bearing to be used in aft cartridge assembly and its location.

Aft Cartridge Assembly

Front Bearing S/N _____.

Rear Bearing S/N _____.

- 5.2.4 Record thickness (b) (see sketch in step 5.2.2) of spacer 1139363-3 and spacer 1139363-4.

1139363-3 (b₁) _____ in.

1139363-4 (b₂) _____ in.

- 5.2.5 Assemble aft bearing cartridge assembly with tooling as shown in sketch (ref. step 5.1.2) using spacer 1139363-2 and 36 springs (1137056-1) located in sequence shown in table and load to 600 pounds in tensile tester. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 5.2.6 Put aft bearing cartridge assembly and tooling into cres flask of LN₂ and check clearance between bearings and cartridge by lifting cartridge with piano wires.

- 5.2.7 When parts return to room temperature, disassemble aft bearing cartridge assembly.

- 5.2.8 Reassemble aft bearing cartridge assembly with tooling as shown in sketch (ref. step 5.2.2) using spacer 1139363-3 (ref. step 5.1.4) and 28 springs (1137056-1) located in sequence shown in table (ref. step 5.1.5). Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

- 5.2.9 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.2.2).

TURBOPUMP ASSEMBLY PROCEDURE

I. INTRODUCTION

This document presents the procedure required for the assembly of the NERVA Turbopump. The procedure is step by step; with appropriate steps requiring sign off by Project and Quality Engineering. The document is complete unto itself, although the referenced (within the procedure) drawings are required to support the assembly.

The work was completed as part of the 121 Project activity and was under the cognicance of P. Pare' and T. Petersen.

II. CONCLUSIONS

The information provided will if carried out, result in a complete turbopump assembly. The adequacy of the procedure cannot be determined until it is implemented; i.e., a turbopump is actually assembled.

III. RECOMMENDATIONS

None

IV. REFERENCES

See text of procedure.

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5.2.10 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (ref. step 5.1.10).

5.2.11 Record load (f_6) and deflection (δ_6) from graph (ref. step 5.1.10) at point where spacer bottoms against bearings. (see sample curve in step 5.1.10).

(f_6) _____ lb.
 (δ_6) _____ in.

5.2.12 Measure with deflectometer and record axial movement (y_6) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_6) _____ in.
 Record load used _____ lb.

5.2.13 Disassemble aft bearing cartridge assembly.

5.2.14 Reassemble aft bearing cartridge assembly with tooling as shown in sketch (ref. step 5.2.2) using spacer 1139363-4 (ref. step 5.1.4) and 28 springs (1137056-1) located in sequence shown on table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.2.15 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.2.2).

5.2.16 Measure load (f) versus deflection (δ) and record on graph as shown in example curve in step 5.1.10.

5.2.17 Record load (f_7) and deflection (δ_7) from graph (ref. step 5.1.16) at point where spacer bottoms against bearings (see sample curve in step 5.1.10).

(f_7) _____ lb.
 (δ_7) _____ in.

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- 5.2.18 Measure with deflectometer and record axial movement (y_7) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_7) _____ in.

Record load used _____ lb.

- 5.2.19 Disassemble aft bearing cartridge assembly and package components to prevent damage.

- 5.2.20 Construct a set of curves of load (f) versus cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with 28 springs and the assumption that the number of springs / load / deflection relationships are linear.

- At (y_6) plot the load (f_6) for 28 springs.
- At (y_7) plot the load (f_7) for 28 springs.
- Connect these points with a straight line.
- Plot values of (f_6) and (f_7) at (y_6) and (y_7) respectively for other number of springs (n) based on the relationship.

$$(f_n) = (f_{28}) \left(\frac{(n)}{28} \right)$$

- Connect these values with straight lines as shown in example curve.

NOTE: Curves must bracket point of $(f) = 600$ lb. and $(y) = .009$ in.

- 5.2.21 From curve (ref. step 5.2.20) select and record number of springs required to result in a load $(f) = 600$ lb. at axial movement $(y) = .009$.

(n_2) _____ springs.

- 5.2.22 Reassemble aft bearing cartridge assembly with tooling as shown in sketch (ref. step 5.2.2) using spacer 1139363-3 (ref. step 5.2.4) and (n_2) springs (ref. step 5.2.21) located in sequence shown on

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5.2.22 (con't) table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.2.23 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.2.2).

5.2.24 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (ref. step 5.1.10)

5.2.25 Record load (f_8) and deflection (δ_8) from graph (ref. step 5.2.24) at point where spacer bottoms against bearings (see sample curve in step 5.1.10).

(f_8) _____ lb.
 (δ_8) _____ in.

5.2.26 Measure and record axial movement (y_8) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_8) _____ in.
Record load used _____ lb.

5.2.27 Disassemble aft bearing cartridge assembly.

5.2.28 Reassemble aft bearing cartridge assembly with tooling as shown in sketch (ref. step 5.2.2) using spacer 1139363-4 (ref. step 5.1.4) and (n_2) springs (ref. step 5.2.21) located in sequence shown on table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.2.29 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.1.10).

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5.2.30 Measure load (f) versus deflection (Δ) and record on graph as shown in example curve in step 5.1.10.

5.2.31 Record load (f_9) and deflection (Δ_9) from graph (ref. step 5.2.30) at point where spacer bottoms against bearings. (see sample curve in step 5.1.10).

(f_9) _____ lb.
 (Δ_9) _____ in.

5.2.32 Measure and record axial movement (y_9) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_9) _____ in.
Record load used _____ lb.

5.2.33 Disassemble aft bearing cartridge assembly and package components to prevent damage.

5.2.34 Construct a set of curves of load (f) versus cartridge axial movement (y) on graph for various numbers of springs (n) based on the data obtained with (n_2) springs and the assumption that the number of springs / load / deflection relationships are linear.

- At (y_8) plot the load (f_8) for (n_2) springs.
- At (y_9) plot the load (f_9) for (n_2) springs.
- Connect these points with a straight line.
- Plot values of (f_8) and (f_9) at (y_8) and (y_9) respectively for $(n_2 - 1)$ springs and $(n_2 + 1)$ springs based on the relationship.

$$(f_n) = (f_{n2}) \left(\frac{(n)}{(n_2)} \right)$$

- Connect these values with straight lines as shown in example curve in step 5.2.20

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- 5.2.35 If the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the $(n_2 - 1)$ line and the $(n_2 + 1)$ line continue with step 5.2.36. If it does not, repeat steps 5.2.20 through 5.2.35 until the point $(f) = 600$ lb. and $(y) = .009$ in. lies between the lines for one less or ~~one~~ more spring then is being used. Record all values and plot all graphs each time.

- 5.2.36 Record number of springs to be used in front cartridge.
_____ Springs (1137056-1)

- 5.2.37 Calculate and record required spacer thickness

$$(b_4) = (b_2) + \frac{(.009 - (y_9)) ((b_1) - (b_2))}{(y_8) - (y_9)}$$

b_4 _____ in.

(b_2) and (y_9) are recorded in step 5.1.4 and 5.2.32 respectively)

- 5.2.38 Grind spacer 1139363-1 to (b_4) dimension per sketch and mark as indicated.

Record actual (b_4) _____ in.

Record serial number _____.

REMOVE ALL BURRS AND SHARP EDGES EQUIVALENT TO .005 - .015 R.

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5.2.39 Reassemble rear bearing cartridge assembly with tooling as shown in sketch (ref. step 5.2.2) using spacer ground from 1139363-1 in step 5.2.38 and number of springs recorded in step 5.2.36 located in sequence shown on table in step 5.1.5. Ensure that high spot marks on inner races are aligned axially and high spot marks on outer races are aligned axially. Ensure that bearings are seated on springs.

5.2.40 Load assembly in tensile tester with deflectometer to measure deflection (see sketch in step 5.2.2).

5.2.41 Measure load (f) versus deflection (δ) and record on graph as shown in example curve (ref. step 5.1.10).

5.2.42 Record load (f_{10}) and deflection (δ_{10}) from graph (ref. step 5.2.41) at point where spacer bottoms against bearings (see sample curve in step 5.1.10).

(f_{10}) _____ lb.

(δ_{10}) _____ in.

NOTE: (f_{10}) should be within 600 ± 25 lb.

5.2.43 Measure and record axial movement (y_{10}) (within $\pm .0001$ in.) of cartridge when moved manually at load indicated on example curve in step 5.1.10.

(y_{10}) _____ in.

Record load used _____ lb.

NOTE: (y_{10}) should be within $.0090 \pm .0001$ in.

5.2.44 Disassemble aft bearing cartridge assembly and package to prevent damage. Assure that all parts are adequately identified to the aft bearing cartridge assembly.

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5.3 BALANCE PISTON TRAVEL AT ROOM TEMPERATURE

5.3.1 Balance piston room temperature travel to be set by grinding aft rub ring shim 1139405-1

5.3.2 Set after bearing housing 1139403-6 in build stand (T1050250-1) with front vertically up.

5.3.3 Measure and record shim 1139405-1 thickness within $\pm .0001$ in, to be used as test shim.

(e) _____ in.

5.3.4 Install aft rub ring (1139353-1) and retaining ring (1139406-) test shim (ref. step 5.3.3) into aft bearing housing (1139403-6)

5.3.5 Install bushing tool T1050210-2 into aft bearing housing.

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- 5.3.6 Install second stage impeller 1139470-1 into aft bearing housing bottoming against aft rub ring and measure and record gap (g) within $\pm .0002$ in.

(g) _____ in.

- 5.3.7 Install rub ring forward 1139414-1 and retaining ring forward 1139410-1 into pump housing 1139403-5

- 5.3.8 Install bushing tool T1050210-1 into pump housing.

- 5.3.9 Warm area of female pilot diameter of flange joint on pump housing to 150°F to 180°F and install onto aft bearing housing.

- 5.3.10 Set up dial indicator and push impeller up and down to measure travel. Measure and record travel (h) within $\pm .0002$ in.

(h) _____ in.

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5.3.11 Travel required = $(j) = .0245 \text{ in.}$

5.3.12 Calculate and record required rub ring shim thickness required.

$$(t) = (e) + (h) - (j)$$

Grind shim 1139405-1 to $(t) \pm .0001 \text{ in.}$ and mark per ASD5215 C with "MOD" following existing part number and actual (t) .

Record actual (t) _____ in.

Record serial number _____.

5.3.13 Calculate and record cavity (k) resulting from shim thickness (t) .

$$(k) = (g) + (t) - (e)$$

(k) _____ in.

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5.4 CARTRIDGE / HOUSING CLEARANCE TEST IN LN₂

5.4.1 Disassemble all parts used in the balance piston travel determination (ref. 5.3). Disassemble pump and aft bearing housings by using three threaded holes in flange (.375 - 24UNJF-3B) for jacking screws.

5.4.2 Install aft bearing housing I139403-6 into build stand assembly T1050250-1

5.4.3 Install second stage impeller I139470-1 (which includes tiebolt and inserts already installed) into aft bearing housing I139403-6

5.4.4 Install "O"-rings in all seal grooves in the housings, three places. (Make "O"-rings from standard "O"-ring stripping).

5.4.5 Warm area of female pilot diameter of flange joint on pump housing I139403-5 to 175° F and install onto aft bearing housing.

5.4.6 Warm area of female pilot diameter of flange joint on turbine inlet housing I139403-7 to 175° F and install onto aft bearing housing with hardware.

5.4.7 Install holding fixture rotor T1050234-1 step 1 onto turbine inlet housing.

5.4.8 Set up assembly vertically with aft end (turbine inlet housing) down and cool front end by pouring LN₂ down hole in impeller shaft.

5.4.9 Install front bearing cartridge assembly (5.1) onto impeller second stage. Ensure that high spot marks on bearing inner race are aligned with 0=0°. (# 1 balance screw hole).

5.4.10 Remove holding fixture rotor T1050234-1 step 1 from turbine inlet housing.

5.4.11 Install holding fixture rotor T1050234-1 step 2 onto pump housing.

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- 5.4.12 Set up assembly vertically with front end (pump housing) down and cool aft end by pouring LN_2 down hole in impeller shaft.
- 5.4.13 Install aft bearing cartridge assembly (5.2) onto impeller, second stage. Ensure that high spot marks on bearing inner races are aligned with $\theta = 0^\circ$. (# 1 balance screw hole) on impeller.
- 5.4.14 Remove holding fixture rotor TI050234-1 step 2 from pump housing.
- 5.4.15 Set assembly in the horizontal position and warm both ends of tiebolt with heat gun to remove moisture. Do not exceed 250°F .
- 5.4.16 Cool adapter I139525-1 in LN_2 and install on front end of impeller, second stage. Ensure that match marks on adapter is aligned with $\theta = 0^\circ$ on impeller.
- 5.4.17 Install cap, retaining I139430-1 onto tool TI050249-1 and heat assembly to 500°F in furnace and install on adapter I139525-1. When parts return to room temperature remove tool.
- 5.4.18 Install lockwasher I139385-1 and nut I139384-1 onto front end of tiebolt finger tight. Do not bend lockwasher tabs.
- 5.4.19 Cool adapter I139526-1 in LN_2 and install on aft end of impeller, second stage.
- 5.4.20 Install cap, retaining I139430-1 onto tool TI050249-1 and heat assembly to 500°F in furnace and install on adapter I139526-1. When parts return to room temperature remove tool.
- 5.4.21 Install lockwasher I139387-1 and nut I139386-1 onto aft end of tiebolt finger tight. Do not bend lockwasher tabs.
- 5.4.22 Hang cylinder TI050263 item 2 from crane in horizontal position.

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- 5.4.23 Insert wrench T1050260-I into thrust sleeve T1050259-I and assemble thrust sleeve to cylinder.
- 5.4.24 Hook up hand pump T1050263 item 15 and associated equipment to cylinder.
- 5.4.25 Fill system with oil T1050263 item 23 and bleed system of air.
- 5.4.26 Insert free end of thrust sleeve over adapter I139525-I. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely against adaptor.
- 5.4.27 Thread pull sleeve T1050258-I onto end of tiebolt finger tight and then back it out 1 turn.
- 5.4.28 Thread measuring rod T1050261-I into end of tiebolt and set up dial indicator.
- 5.4.29 Using hand pump, extend cylinder ram to take up clearance between ram and collar on pull sleeve T1050258-I. Ensure that thrust sleeve is seated squarely against adapter and aligned freely against adapter.
- 5.4.30 Using hand pump, stretch tiebolt until pressure gage reads 3000 psi.
- 5.4.31 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand).
- 5.4.32 Record dial indicator reading, $E = \underline{\hspace{2cm}}$ in.
- 5.4.33 Compute and record, $F = E + D + .030 = \underline{\hspace{2cm}}$ in.

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5.4.34 Using hand pump, stretch bolt until indicator reading is F. Record actual F = _____ in. Record cylinder pressure = _____ psi.
NOTE: DO NOT EXCEED 3700 psi.

5.4.35 Turn nut 1139384-1 up by hand using wrench T1050260-1.

5.4.36 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand)

5.4.37 Record dial indicator reading, G = _____ in.

5.4.38 Compute and record, $H = G - E =$ _____ in.

5.4.39 If $H = .030 \pm .001$, go to step 5.4.47. If not, continue with step 5.4.40.

5.4.40 Compute and record $.030 - H =$ _____ in.

5.4.41 Using hand pump, stretch bolt until indicator reading is $F_1 = F + .030 - H =$ _____ in. (Nut may have to be loosened). Record actual $G_1 =$ _____ in. Record cylinder pressure _____ psi. NOTE: DO NOT EXCEED 3700 PSI.

5.4.42 Turn nut up by hand using wrench.

5.4.43 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify as in 5.4.31).

5.4.44 Record indicator reading, $G_1 =$ _____ in.

5.4.45 Compute and record $H_1 = G_1 - F =$ _____ in.

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5.4.46 If $H_1 = .030 \pm .001$, go to step 5.4.47. If not, repeat steps 5.4.40 through 5.4.46. Record all values each time.

5.4.47 Remove dial indicator and unscrew measuring rod T1050261-1.

5.4.48 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.

5.4.49 Insert free end of thrust sleeve T1050259-1 over adaptor I139526-1.

5.4.50 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.

5.4.51 Thread measuring rod T1050261-1 onto end of tiebolt and set up dial indicator.

5.4.52 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor, and aligned freely against adaptor.

5.4.53 Using hand pump, stretch tiebolt until pressure gage reads 2750 psi.

5.4.54 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand).

5.4.55 Record dial indicator reading, $J =$ _____ in.

5.4.56 Compute and record $K = J + C + .018 =$ _____ in.

5.4.57 Using hand pump, stretch bolt until indicator reading is K . Record actual $K =$ _____ in. Record cylinder pressure = _____ psi.
NOTE: DO NOT EXCEED 3700 PSI.

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- 5.4.58 Turn nut 1139386-1 up by hand using wrench T1050260-1.
- 5.4.59 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand).
- 5.4.60 Record dial indicator reading, $L =$ _____ in.
- 5.4.61 Compute and record $M = L - K =$ _____ in.
- 5.4.62 If $M = .018 \pm .001$, go to step 5.4.69. If not, continue with step 5.4.63.
- 5.4.63 Compute and record $.018 - N =$ _____ in.
- 5.4.64 Using hand pump, stretch bolt until indicator reading is
 $K_1 = K + .018 - N =$ _____ in. (Nut may have to be loosened).
 Record actual $L_1 =$ _____ in.
 Record cylinder pressure _____ psi.
 NOTE: DO NOT EXCEED 3700 PSI.
- 5.4.65 Turn nut by hand using wrench.
- 5.4.66 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify as in 5.4.59).
- 5.4.67 Record dial indicator reading $L_1 =$ _____ in.
- 5.4.68 Compute and record $M_1 = L_1 - J =$ _____ in.
 If $M_1 = .018 \pm .001$, go to step 5.4.69. If not, repeat steps 5.4.63 through 5.4.68 until it is. Record all values each time.
- 5.4.69 Remove dial indicator and unscrew measuring rod T1050261-1.

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- 5.4.70 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.
- 5.4.71 Install manifold balance piston drain I139440-1 and associated hardware.
- 5.4.72 Warm area of female pilot diameter of flange joint on inducer housing I139390-1 to 175° F and install onto pump housing with hardware.
- 5.4.73 Install hydrostatic test cover T1050217-1 and "O"-ring MS29561-452 on turbine inlet housing with hardware.
- 5.4.74 All ports to be plugged with appropriate plugs. For plug information see appropriate housing detail drawing, hydrostatic proof test assembly.
- 5.4.75 Install rod rotor friction (T1050246-1) onto front end of tiebolt.
- 5.4.76 With inducer housing (pump inlet) in the vertically up position, fill with LN₂ thru turbine inlet and pump discharge, with suitable vents. Note stabilized condition by location of frost line on pipe.
- 5.4.77 After assembly has achieved LN₂ temperature, check cartridges to housing fits by lifting rotor in housing. Fits must be free.

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5.5 DISASSEMBLY OF CARTRIDGE / HOUSING CLEARANCE TEST

- 5.5.1 Install assembly onto build stand T1050250-1 and remove rod rotor friction (T1050246-1).
- 5.5.2 Remove inducer housing and associated hardware. Three (.375 - 24UNJF-3B) threaded holes are provided in flange for disassembly by jacking screws.
- 5.5.3 Remove manifold balance piston drain I139440-1 and associated hardware.
- 5.5.4 Remove all plugs from ports.
- 5.5.5 Remove hydrostatic test cover and associated hardware.
- 5.5.6 Insert free end of thrust sleeve T1050259-1 over adaptor I139526-1.
- 5.5.7 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.
- 5.5.8 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.
- 5.5.9 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 5.5.10 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 5.4.57 or 5.4.64, whichever is higher.
- 5.5.11 Back off nut I139386-1 by using wrench T1050260-1.
- 5.5.12 Remove dial indicator and unscrew measuring rod T1050261-1.

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- 5.5.13 Unscrew pull sleeve T1050258-I and remove bolt stretcher.
- 5.5.14 Remove nut I139386 and lockwasher I139387.
- 5.5.15 Assemble puller T1050265-I on cap retaining I139430-I and remove cap.
- 5.5.16 Assemble puller T1050244 step I onto rotor and remove adaptor I139526-I.
- 5.5.17 Set up bolt stretcher on crane at front end of impeller, second stage.
- 5.5.18 Insert free end of thrust sleeve T1050259-I over adaptor I139525-I
- 5.5.19 Thread pull sleeve T1050258-I onto end of tiebolt finger tight and then back it out 1 turn.
- 5.5.20 Thread measuring rod T1050261-I into end of tiebolt and set up dial indicator.
- 5.5.21 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 5.5.22 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 5.4.34 or 5.4.41, whichever is higher.
NOTE: DO NOT EXCEED 3700 PSI.
- 5.5.23 Back off nut I139384-I by using wrench T1050260-I.
- 5.5.24 Remove dial indicator and unscrew measuring rod T1050261-I.
- 5.5.25 Unscrew pull sleeve T1050258-I and remove bolt stretcher.

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- 5.5.26 Remove nut I139384-1 and lockwasher I139385-1.
- 5.5.27 Assemble puller T1050265-1 on cap retaining I139430-1 and remove cap.
- 5.5.28 Assemble puller T1050244 step 2 onto rotor and remove adaptor I139525-1.
- 5.5.29 Install holding fixture, rotor T1050234-1 step 1 onto turbine inlet housing.
- 5.5.30 Remove front bearing cartridge assembly from second stage impeller using tools T1050229-1 step 2, T1050230-1 and T1050267-1 and package to prevent damage. Assure that all parts are adequately identified to front bearing cartridge assembly.
- 5.5.31 Remove holding fixture, rotor (T1050234-1 step 1) from turbine inlet housing.
- 5.5.32 Install holding fixture, rotor T1050234-1 step 2 onto pump housing.
- 5.5.33 Remove aft bearing cartridge assembly from second stage impeller using tools T1050229-1 step 2, T1050230-1 and T1050267-1 and package to prevent damage. Assure that all parts are adequately identified to aft bearing cartridge assembly.
- 5.5.34 Remove holding fixture rotor step 2 from pump housing.
- 5.5.35 Remove turbine inlet housing and pump housing from aft bearing housing, disassemble same as 5.5.2.
- 5.5.36 Remove second stage impeller assembly from aft bearing housing.
- 5.5.37 Do not remove tiebolt and inserts from second stage impeller.

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5.6 INITIAL PUSH - PULL TEST ASSEMBLY

5.6.1 With aft bearing housing mounted on build stand (TI050250-1) install aft rub ring 1139353-1 and retaining ring 1139406 with modified shim 1139405-1 (ref. step 5.3.12) into aft bearing housing.

5.6.2 Grind shim 1139479-1 to $.0820 \pm .0001$ in. and mark per ASD5215 C with "MOD" following existing part number and actual thickness.

Record thickness _____ in.

Record serial number _____.

5.6.3 Install labyrinth, aft bearing inboard 1139411-1 with modified shim 1139479-1 (ref. step 5.6.2) into aft bearing housing.

5.6.4 Install rub ring, forward 1139414-1 and retaining ring, forward 1139410-1 into pump housing 1139403-5.

5.6.5 Grind shim 1139481-1 to (thickness to be determined by cognizant engineer) $\pm .0001$ in. and mark per ASD5215 with "MOD" following existing part number and actual thickness.

Record thickness _____ in.

Record serial number _____.

5.6.6 Install fairing ring 1139436-1, modified shim 1139481-1 (ref. step 5.6.5) and labyrinth, second stage impeller (1139412-1) into pump housing 1139403-5.

5.6.7 Install second stage impeller (which already includes tie bolt and inserts installed) into aft bearing housing.

5.6.8 Warm area of female pilot diameter of flange joint on pump housing to 175° F and install onto aft bearing housing. Bolt up assembly.

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- 5.6.9 Set up assembly vertically with aft end down and cool front end by pouring LN₂ down hole in impeller shaft.
- 5.6.10 Install front bearing cartridge assembly (5.1) onto second stage impeller. Ensure that high spot marks on bearing inner race are aligned with 0 = 0°. (Number 1 balance screw hole).
- 5.6.11 Set up assembly vertically with front end (pump housing) down and cool aft end by pouring LN₂ down hole in impeller shaft.
- 5.6.12 Install aft bearing cartridge assembly (5.2) onto second stage impeller. Ensure that high spot marks on bearing inner races are aligned with 0 = 0° (number 1 balance screw hole) on impeller.
- 5.6.13 Set assembly in the horizontal position and warm both ends of tie bolt with heat gun to remove moisture. Do not exceed 250° F.
- 5.6.14 Cool adapter 1139525-1 in LN₂ and install on front end of second stage impeller. Ensure that match marks on adapter is aligned with 0 = 0° on impeller.
- 5.6.15 Install retaining cap 1139430-1 onto tool T1050249-1 and heat assembly to 500° F in furnace and install on adaptor 1139525-1. When parts return to room temperature, remove tool.
- 5.6.16 Install lockwasher 1139385-1 and nut 1139384-1 onto front end of tie bolt finger tight. Do not bend lockwasher tabs.
- 5.6.17 Cool adaptor 1139526-1 in LN₂ and install on aft end of second stage impeller.
- 5.6.18 Install retaining cap 1139430-1 onto tool T1050249-1 and heat assembly to 500° F in furnace and install on adaptor 1139526-1. When parts return to room temperature, remove tool.

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5.6.19 Install lockwasher I139387-1 and nut I139386-1 onto aft end of tie bolt finger tight. Do not bend lockwasher tabs.

5.6.20 Hang cylinder T1050263 item 2 from crane in horizontal position.

5.6.21 Insert wrench T1050260-1 into thrust sleeve T1050259-1 and assemble thrust sleeve to cylinder.

5.6.22 Hook up hand pump T1050263 item 15 and associated equipment to cylinder.

5.6.23 Fill system with oil T1050263 item 23 and bleed system of air.

5.6.24 Insert free end of thrust sleeve over adaptor I139525-1. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely against adaptor.

5.6.25 Thread pull sleeve T1050258-1 onto end of tie bolt finger tight and then back out 1 turn.

5.6.26 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

5.6.27 Using hand pump, extend cylinder ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

5.6.28 Using hand pump, stretch tie bolt until pressure is at cylinder pressure in step 5.4.34 or 5.4.41, whichever is higher.

5.6.29 Turn nut by hand using wrench T1050260-1.

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- 5.6.30 Release oil pressure until clearance between ram and collar on sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)
- 5.6.31 Remove dial indicator and unscrew measuring rod T1050261-I.
- 5.6.32 Unscrew pull sleeve T1050258-I and remove bolt stretcher. Do not bend lockwasher tabs.
- 5.6.33 Insert free end of thrust sleeve T1050259-I over adaptor I139526-I.
- 5.6.34 Install spacer T1050262-I into pull sleeve T1050258 and thread onto end of tie bolt finger tight and then back it out 1 turn.
- 5.6.35 Thread measuring rod T1050261-I into end of tie bolt and set up dial indicator.
- 5.6.36 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 5.6.37 Using hand pump, stretch tie bolt until pressure is at cylinder pressure in step 5.4.57 or 5.4.64, whichever is higher.
- 5.6.38 Turn nut up by hand using wrench T1050260-I.
- 5.6.39 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)
- 5.6.40 Remove dial indicator and unscrew measuring rod T1050261-I.
- 5.6.41 Unscrew pull sleeve T1050258-I and remove bolt stretcher. Do not bend lockwasher tabs.

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5.6.42 Install modified push - pull fixture T1050226-1 step 2 on aft end of assembly and load to 1500 ± 25 pounds. Record load and measure and record gap (p) within $\pm .0002$ in.

Load _____ pounds

(p) _____ in.

Ensure that second stage impeller is touching aft rub ring 1139353-1 in aft bearing housing prior to applying above load.

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5.6.43 Calculate and record required shim, bayonet thickness required

$$\textcircled{L} = \textcircled{p} \pm \textcircled{z}$$

5.6.43.1 $\textcircled{z}$ = correction to set dead band travel in the correct position relative to total rub ring travel (ref. step 5.3.II) to be determined by cognizant engineer.

5.6.43.2 Grind shim, bayonet I139473-I to $\textcircled{L} \pm .0001$ in. and mark per ASD5215 C with "MOD" following existing part number and actual $\textcircled{L}$.

Record actual $\textcircled{L}$ _____ in.

Record serial number _____.

5.6.44 Calculate and record required bayonet ring I139367-I thickness

$$\textcircled{m} = \textcircled{d} - \textcircled{w} \pm \textcircled{n}$$

5.6.44.1 $\textcircled{d}$ = see step 5.2.2

5.6.44.2 $\textcircled{w}$ = Extra dead band travel needed to give total dead band travel required (ref. step 5.6.43). Must be a minimum of .0014 so that bayonet ring will fit freely into cartridge groove. To be determined by cognizant engineer.

5.6.44.3 $\textcircled{n}$ = Correction to dead band travel to check for front rub ring touching with shaft loaded forward 1500 pounds in LN_2 . To be determined by cognizant engineer.

5.6.44.4 Grind bayonet ring to $\textcircled{m} \pm .0001$ in. and mark per ASD5215 C with "MOD" following existing part number and actual thickness. Grind only surface indicated on I139367-I.

Record actual $\textcircled{m}$ _____ in.

Record serial number _____.

5.6.45 Remove push - pull fixture T1050266-I step 2 from assembly.

5.6.46 Install shim, bayonet (ref. step 5.6.43), bayonet ring (ref. step 5.6.44) and inner shield I139409-I and bolt up.

5.6.47 Unbolt assembly (ref. step 5.6.8) so as to assemble step 5.6.48.

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FORWARD DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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FOWARD DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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5.6.48 Warm area of female pilot diameter of flange joint on turbine inlet housing II39403-7 to 175° F and install onto aft bearing housing with hardware.

5.6.49 Install manifold balance piston drain II39440-1 and associated hardware.

5.6.50 Warm area of female pilot diameter of flange joint on inducer housing II39403-3 to 175° F and install onto pump housing with hardware.

5.6.51 Install hydrostatic test cover TI050217-1 and "O"-ring MS29561-452 on turbine inlet housing with hardware.

5.6.52 All ports to be plugged with appropriate plugs. For plug information see appropriate housing detail drawing. Hydrostatic proof test assembly

5.6.53 Measure and record breakaway and running torque on shaft at room temperature.

Breakaway torque = _____.

Running torque = _____.

5.6.54 Install push - pull fixture TI050266-1 step 1 onto front end of assembly (inducer housing). Rotate assembly to the vertically up position.

5.6.55 Check for indications of shaft rubbing (such as noise or regions where shaft feels hard to turn) by rotating the shaft.

5.6.56 Push the shaft forward with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.6.55.

5.6.57 Pull the shaft aft with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.6.55.

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5.6.58 Perform push - pull test by loading the shaft as indicated in table.

NOTE: If any target load is exceeded, do not reverse the loading direction to achieve the target load. Record the actual load and shaft movement at each target load in table.

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- 5.6.59 Measure and record the dead band travel by pushing and pulling the shaft through the region of nearly zero load. The dead band travel is the total motion measured while the load is approximately constant and nearly zero.

Dead band travel _____ in.

- 5.6.60 Fill assembly with LN₂ thru turbine inlet and pump discharge with suitable vents. Note stabilized condition by location of frost line on pipe.

- 5.6.61 Check for indications of shaft rubbing (such as noise or regions where shaft feels hard to turn) by rotating the shaft.

- 5.6.62 Push the shaft forward with loads of 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.6.61.

- 5.6.63 Pull the shaft aft with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.6.61.

- 5.6.64 Perform push - pull test by loading the shaft as indicated in table.
NOTE: If target load is exceeded, do not reverse the loading direction to achieve the target load. Record the actual load and shaft movement at each target load in table.

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FOWARD DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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FOWARD DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0		

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- 5.6.65 Measure and record the dead band travel by pushing and pulling the shaft through the region of nearly zero load. The dead band travel is the total motion measured while the load is approximately constant and nearly zero.

Dead band travel _____ in.

- 5.6.66 Disconnect LN₂ supply and drain assembly.

- 5.6.67 If test meets requirements of 5.6.44, shim and bayonet ring will be used in final turbopump assembly. To be determined by cognizant engineer.

- 5.6.68 If 5.6.67 is not achieved, repeat steps 5.6.43 through 5.6.65 until it does. Record all values each time.

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5.7 DISASSEMBLY OF INITIAL PUSH - PULL TEST

- 5.7.1 Install assembly onto build stand T1050250-1 and remove push - pull fixture T1050266-1 step 1.
- 5.7.2 Remove inducer housing and associated hardware. Three (.375 - 24UNJF -3B) threaded holes are provided in flange for disassembly by jacking screws.
- 5.7.3 Remove manifold , balance piston drain I139440-1 and associated hardware.
- 5.7.4 Remove all plugs from ports.
- 5.7.5 Remove hydrostatic test cover and associated hardware.
- 5.7.6 Insert free end of thrust sleeve T1050259-1 over adaptor I139526-1.
- 5.7.7 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.
- 5.7.8 Thread measuring rod T1050261-1 into end of tiebolt and set up dial indicator.
- 5.7.9 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve . Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.
- 5.7.10 Using hand pump, Stretch tiebolt until pressure is at cylinder pressure in step 5.4.57 or 5.4.64, whichever is higher.
- 5.7.11 Back off nut I139386-1 by using wrench T1050260-1.
- 5.7.12 Remove dial indicator and unscrew measuring rod T1050261-1.

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5.7.13 Unscrew pull sleeve T1050258-I and remove bolt stretcher.

5.7.14 Remove nut I139386 and lockwasher I139387.

5.7.15 Assemble puller T1050265-I on retaining cap I139430-I and remove cap.

5.7.16 Assemble puller T1050244 step I onto rotor and remove adaptor I139526-I.

5.7.17 Set up bolt stretcher on crane at front end of second stage impeller.

5.7.18 Insert free end of thrust sleeve T1050259-I over adaptor I139525-I.

5.7.19 Thread pull sleeve T1050258-I onto end of tiebolt finger tight and then back it out 1 turn.

5.7.20 Thread measuring rod T1050261-I into end of tiebolt and set up dial indicator.

5.7.21 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

5.7.22 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 5.4.34 or 5.4.41, whichever is higher.

5.7.23 Back off nut I139384-I by using wrench T1050260-I.

5.7.24 Remove dial indicator and unscrew measuring rod T1050261-I.

5.7.25 Unscrew pull sleeve T1050258-I and remove bolt stretcher.

5.7.26 Remove nut I139384-I and lockwasher I139385-I.

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- 5.7.27 Assemble puller TI050265-1 on retaining cap I139430-1 and remove cap.
- 5.7.28 Assemble puller TI050244 step 2 onto rotor and remove adaptor I139525-1.
- 5.7.29 Install holding fixture, rotor (TI050234-1) step 1 onto turbine inlet housing.
- 5.7.30 Remove front bearing cartridge assembly from second stage impeller using tools TI050229-1 step 2, TI050230-1 and TI050267-1 and package to prevent damage. Assure that all parts are adequately identified to front bearing cartridge assembly.
- 5.7.31 Remove holding fixture, rotor (TI050234-1) step 1 from turbine inlet housing.
- 5.7.32 Install rotor holding fixture TI050234-1 step 2 onto pump housing.
- 5.7.33 Remove inner shield I139409-1, bayonet ring and bayonet shim from aft bearing housing. Package to prevent damage and assure that all parts are adequately identified.
- 5.7.34 Remove aft bearing cartridge assembly from second stage impeller using tools TI050229-1 step 2, TI050230-1 and TI050267-1 and package to prevent damage. Assure that all parts are adequately identified to aft bearing cartridge assembly.
- 5.7.35 Remove holding fixture, rotor (TI050234-1) step 2 from pump housing.
- 5.7.36 Remove turbine inlet housing and pump housing from aft bearing housing. Disassemble same as 5.7.2.

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5.7.37 Do not remove fairing ring 1139436-1, shim 1139481-1, labyrinth 1139412-1, forward rub ring 1139414-1 and forward retaining ring from pump housing 1139403-5.

5.7.38 Do not remove labyrinth, aft bearing inboard 1139411-1, shim 1139479-1, aft rub ring 1139353-1, retaining ring 1139406-1 and shim 1139405-1 from aft bearing housing.

5.7.39 Remove impeller, second stage assembly from aft bearing housing.

5.7.40 Do not remove tiebolt and inserts from second stage impeller.

5.7.41 Package all parts to prevent damage prior to final assembly and assure that all parts are adequately identified to this assembly build up.

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5.8 FINAL ASSEMBLY

5.8.1 Install aft bearing housing (ref. step 5.7.39) onto build stand T1050250-1 for final build up. Install internal instrumentation (transducers, thermocouples and etc.) into aft bearing housing.

5.8.2 Using pump housing (ref. step 5.7.38) install inboard forward bearing labyrinth 1139413-1, seal 1139429-1, outboard forward bearing labyrinth 1139472-1 and seal 1139429-2. Install internal instrumentation into pump housing.

5.8.3 Install second stage impeller (ref. step 5.7.41) into aft bearing housing 1139403-6.

5.8.4 Warm area of female pilot diameter of flange joint on pump housing to 175° F and install onto aft bearing housing including seal 1139429-5.

5.8.5 Install first stage stator 1139403-8 and first stage stator seal 1139431-1 with hardware into turbine inlet housing.

5.8.6 Warm area of female pilot diameter of flange joint on turbine inlet housing to 175° F and install onto aft bearing housing including seal 1139429-4 with associated hardware.

5.8.7 Install rotor holding fixture T1050234-1 step 1 onto turbine inlet housing.

5.8.8 Set up assembly vertically with aft end (turbine inlet housing) down and cool front end by pouring LN₂ down hole in impeller shaft.

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- 5.8.9 Install front bearing cartridge assembly (5.1) onto second stage impeller. Ensure that high spot marks on bearing inner race are aligned with $0 = 0^0$. (Number 1 balance screw hole).
- 5.8.10 Remove rotor holding fixture T1050234-1 step 1 from turbine inlet housing.
- 5.8.11 Install rotor holding fixture T1050234-1 step 2 onto pump housing.
- 5.8.12 Set up assembly vertically with front end (pump housing) down and cool aft end by pouring LN_2 down hole in impeller shaft.
- 5.8.13 Install aft bearing cartridge assembly (5.2) onto second stage impeller. Ensure that high spot marks on bearing inner races are aligned with $0 = 0^0$ (number 1 balance screw hole) on impeller.
- 5.8.14 Remove rotor holding fixture T1050234-1 step 2 from pump housing.
- 5.8.15 Set assembly in the horizontal position and warm both ends of tiebolt with heat gun to remove moisture. Do not exceed $250^0 F$.
- 5.8.16 Cool adaptor I139525-1 in LN_2 and install on front end of second stage impeller. Ensure that match marks on adaptor is aligned with $0 = 0^0$ on impeller.
- 5.8.17 Install retaining cap I139430-1 onto tool T1050249-1 and heat assembly to $500^0 F$ in furnace and install on adaptor I139525-1. When parts return to room temperature, remove tool.
- 5.8.18 Install lockwasher I139385-1 and nut I139384-1 onto front end of tiebolt finger tight. Do not bend lockwasher tabs.

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- 5.8.19 Cool adaptor I139526-I in LN₂ and install on aft end of second stage impeller.
- 5.8.20 Install retaining cap I139430-I onto tool T1050249-I and heat assembly to 500° F in furnace and install on adaptor I139526-I. When parts return to room temperature, remove tool.
- 5.8.21 Install lockwasher I139387-I and nut I139386-I onto aft end of tiebolt finger tight. Do not bend lockwasher tabs.
- 5.8.22 Hang cylinder T1050263 item 2 from crane in horizontal position.
- 5.8.23 Insert wrench T1050260-I into thrust sleeve T1050259-I and assemble thrust sleeve to cylinder.
- 5.8.24 Hook up hand pump T1050263 item 15 and associated equipment to cylinder.
- 5.8.25 Fill system with oil T1050263 item 23 and bleed system of air.
- 5.8.26 Insert free end of thrust sleeve over adaptor I139525-I. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely against adaptor.
- 5.8.27 Thread pull sleeve T1050258-I onto end of tiebolt finger tight and then back it out 1 turn.
- 5.8.28 Thread measuring rod T1050261-I onto end of tiebolt and set up dial indicator.
- 5.8.29 Using hand pump, extend cylinder ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

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5.8.30 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 5.4.34 or 5.4.41, whichever is higher.

5.8.31 Turn nut up by hand using wrench.

5.8.32 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)

5.8.33 Remove dial indicator and unscrew measuring rod T1050261-I.

5.8.34 Unscrew pull sleeve T1050258-I and remove bolt stretcher. Do not bend lockwasher tabs.

5.8.35 Install bayonet shim (ref. step 5.6.43), bayonet ring (ref. step 5.6.44) and inner shield I139409-I and bolt up.

5.8.36 The following dimensions, (A) , (B) , and (C) are to be taken with the rotor positioned as follows: Rear face of aft inboard bearing touching cartridge and inboard face of groove in cartridge touching bayonet ring.

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5.8.37 Measure and record dimension (A) within $\pm .0002$ in. on pump rotor subassembly 1139398-4 as shown.

(A) _____ in.

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5.8.3/8 Measure and record dimensions (B) and (C) within $\pm .0002$ in. as shown. Measure dimension (C) at three points.

(B) _____ in.
(C) _____ in.

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5.8.39 Gap required between pump rotor subassembly I139398-4 and pump housing I139403-5 = .015 in.

5.8.40 Calculate and record shim thickness T required.

$$(T) = .015 + (B) - (C) - (A)$$

5.8.41 Grind shim I139407-1 to $(T) \pm .0001$ in. and mark per ASD5215 C with "MOD" following existing part number and actual (T) .

Record actual (T) _____ in.

Record serial number _____.

5.8.42 Set up bolt stretcher on crane at front end of second stage impeller.

5.8.43 Insert free end of thrust sleeve T1050259-1 over adaptor I139525-1.

5.8.44 Thread pull sleeve T1050258-1 onto end of tiebolt finger tight and then back it off 1 turn.

5.8.45 Thread measuring rod T1050261-1 onto end of tiebolt and set up dial indicator.

5.8.46 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against adaptor and aligned freely against adaptor.

5.8.47 Using hand pump, stretch tiebolt until pressure is at cylinder pressure in step 5.4.34 or 5.4.41, whichever is higher.

NOTE: Do not exceed 3700 psi.

5.8.48 Back off nut I139384-1 by using wrench T1050260-1.

5.8.49 Remove dial indicator and unscrew measuring rod T1050261-1.

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- 5.8.50 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.
- 5.8.51 Remove nut 1139384-1 and lockwasher 1139385-1.
- 5.8.52 Assemble puller T1050265-1 on retaining cap 1139430-1 and remove cap.
- 5.8.53 Assemble puller T1050244 step 2 onto rotor and remove adaptor 1139525-1
- 5.8.54 Install shim 1139407-1 (ref. step 5.8.41) onto front end of second stage impeller.
- 5.8.55 Cool aft end of pump rotor subassembly 1139398-4 in LN₂ and warm front end of second stage impeller to 250° F with heat gun (do not heat tiebolt) and install pump rotor into second stage impeller.
- 5.8.56 Warm ends of tiebolt with heat gun to remove moisture. Do not exceed 250° F.
- 5.8.57 Install retaining cap 1139430-1 onto tool T1050249-1 and heat assembly to 500° F in furnace and install onto pump rotor subassembly. When parts return to room temperature, remove tool.
- 5.8.58 Install lockwasher 1139385-1 and nut 1139384-1 finger tight using wrench T1050254-1 onto front end of tiebolt. Do not bend lockwasher tabs.
- 5.8.59 Set up bolt stretcher at front end of inducer.
- 5.8.60 Insert free end of thrust sleeve into inducer. Ensure that cylinder is positioned correctly so that thrust sleeve is aligned freely inside inducer.

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5.8.61 Thread pull sleeve T1050258-I onto end of tiebolt finger tight and then back it out 1 turn.

5.8.62 Thread measuring rod T1050261-I into end of tiebolt and set up dial indicator.

5.8.63 Using hand pump, extend cylinder ram to take up clearance between ram and collar on pull sleeve T1050258-I. Ensure that thrust sleeve is seated squarely against first stage impeller and aligned freely inside inducer.

5.8.64 Using hand pump, stretch tiebolt until pressure gage reads 3000 psi.

5.8.65 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand.)

5.8.66 Record dial indicator reading, $E =$ _____ in.

5.8.67 Compute and record, $F = E + D + .030 =$ _____ in.

5.8.68 Using hand pump, stretch bolt until indicator reading is F.

Record actual $F =$ _____ in.

Record cylinder pressure = _____ psi.

NOTE: DO NOT EXCEED 3700 PSI.

5.8.69 Turn nut I139384-I up by hand using wrench T1050260-I.

5.8.70 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand).

5.8.71 Record dial indicator reading, $G =$ _____ in.

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- 5.8.72 Compute and record, $H = G - E =$ _____ in.
- 5.8.73 If $H = .030 \pm .001$ go to step 5.8.81. If not, continue with step 5.8.74.
- 5.8.74 Compute and record $.030 - H =$ _____ in.
- 5.8.75 Using hand pump, stretch bolt until indicator reading is $F_1 = F + .030 - H =$ _____ in. (Nut may have to be loosened.)
Record actual $G_1 =$ _____ in.
Record cylinder pressure _____ psi.
NOTE: DO NOT EXCEED 3700 PSI.
- 5.8.76 Turn nut up by hand using wrench.
- 5.8.77 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 5.8.65.
- 5.8.78 Record indicator reading, $G_1 =$ _____ in.
- 5.8.79 Compute and record $H_1 = G_1 - F =$ _____ in.
- 5.8.80 If $H_1 = .030 \pm .001$, go to step 5.8.81. If not, repeat steps 5.8.74 through 5.8.80 until it is. Record all values each time.
- 5.8.81 Remove dial indicator and unscrew measuring rod TI050261-1.
- 5.8.82 Unscrew pull sleeve TI050258-1 and remove bolt stretcher. Bend lockwasher tabs.
- 5.8.83 Cool spinner I139383-1 in LN_2 and install on inducer (pump rotor subassembly I139398-4).

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5.8.84 When parts return to room temperature, install washer 1139463-1 and bolt 1139464-1. Torque bolt to drawing requirements. Bend lockwasher tabs.

5.8.85 Install split inducer shroud 1139393-1 and inducer shroud retaining ring 1139435-1 using tool T1050227-1 around inducer.

5.8.86 Warm inducer housing 1139403-3 to 175° F. Install around inducer shroud and onto pump housing which includes seal 1139429-6 using tool T1050227-1.

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- 5.8.87 Cool inducer liner 1139391-1 in LN_2 and install into inducer.
Ensure that liner is seated squarely against retaining ring 1139435-1.

- 5.8.88 When parts return to room temperature, install inducer housing locknut 1139433-1 and lockwasher 1139434-1. Torque locknut to drawing requirements. Bend lockwasher tabs.

- 5.8.89 Check clearance between inner shield 1139409-1 and first stage turbine rotor (part of turbine rotor subassembly 1139398-5).

- 5.8.90 Measure and record dimensions (Y) and (Z) within $\pm .005$ in. as shown. Measure (Y) dimension with second stage rotor pushed forward (by hand).

(Y) = _____ in.
(Z) = _____ in.

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5.8.91 Calculate and record gap (W) .

$$(W) = (Z) - (Y)$$

(W) must be .030 / .060.

Record actual (W) = _____ in.

5.8.92 Back off nut I139386-1 (that was installed finger tight in step 5.8.21), may use wrench T1050260-1.

5.8.93 Remove nut I139386-1 and lockwasher I139387-1.

5.8.94 Assemble puller T1050265-1 on retaining cap I139430-1 and remove cap.

5.8.95 Install puller T1050244 step 1 onto rotor and remove adaptor I139526-1.

5.8.96 Assemble second stage stator I139403-10, first stage spacer I139403-11, second stage spacer I139403-9, stator key I139366-1 (2 required) onto turbine rotor subassembly using tool T1050253-1 step 1.

5.8.97 Using T1050253-1 step 2 cool entire assembly in LN₂ and warm front end of second stage impeller to 250° F with heat gun (do not heat tiebolt) and install assembly into second stage impeller and turbine inlet housing. Ensure that key is inline with slot in turbine inlet housing.

5.8.98 Warm ends of tiebolt with heat gun to remove moisture. Do not exceed 250° F.

5.8.99 Install retaining cap I139430-1 onto tool T1050249-1 and heat assembly to 500° F in furnace and install onto turbine rotor subassembly. When parts return to room temperature, remove tool.

5.8.100 Install lockwasher I139387-1 and nut I139386-1 finger tight. Do not bend lockwasher tabs.

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5.8.101 Set up bolt stretcher on crane at turbine location.

5.8.102 Insert free end of thrust sleeve TI050259-I into second stage turbine.

5.8.103 Install spacer TI050262-I into pull sleeve TI050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.

5.8.104 Thread measuring rod TI050261-I into end of tiebolt and set up dial indicator.

5.8.105 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against first stage turbine and aligned freely inside second stage turbine.

5.8.106 Using hand pump, stretch tiebolt until pressure gage reads 2750 psi.

5.8.107 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve TI050259 by hand).

5.8.108 Record dial indicator reading, $J =$ _____ in.

5.8.109 Compute and record $K = J + C + .018 =$ _____ in.

5.8.110 Using hand pump, stretch bolt until indicator reading is K .

Record actual $K =$ _____ in.

Record cylinder pressure = _____ psi.

NOTE: DO NOT EXCEED 3700 PSI.

5.8.111 Turn nut I139386-I up by hand using wrench TI050260-I.

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5.8.112 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.

5.8.113 Record dial indicator reading, $L =$ _____ in.

5.8.114 Compute and record $M = L - K =$ _____ in.

5.8.115 If $M = .018 \pm .001$ go to step 5.8.122. If not, continue with step 5.8.116.

5.8.116 Compute and record $.018 - N =$ _____ in.

5.8.117 Using hand pump, stretch bolt until indicator reading is $K_1 = K + .018 - N =$ _____ in.
(Nut may have to be loosened.)

Record actual $L_1 =$ _____ in.

Record cylinder pressure _____ psi.

NOTE: DO NOT EXCEED 3700 PSI.

5.8.118 Turn nut up by hand using wrench.

5.8.119 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in 5.8.112.

5.8.120 Record dial indicator reading $L_1 =$ _____ in.

5.8.121 Compute and record $M_1 = L_1 - J =$ _____ in.
If $M_1 = .018 \pm .001$, go to step 5.8.122. If not, repeat steps 5.8.115 through 5.8.121 until it is. Record all values each time.

5.8.122 Remove dial indicator and unscrew measuring rod TI050261-1.

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5.8.123 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.

5.8.124 Measure and record dimensions (R) and (S) within $\pm .0002$ as shown. The rotor should be positioned in the aft position with 2nd stage impeller touching aft rub ring.

(R) = _____ in.
(S) = _____ in.

5.8.125 Calculate and record lockwasher 1139387-1 thickness (R₁) required.

$$(R_1) = (R) - (S) - .040$$

5.8.126 Insert free end of thrust sleeve T1050259-1 into turbine, 2nd stage.

5.8.127 Install spacer T1050262-1 into pull sleeve T1050258-1 and thread onto end of tie bolt finger tight and then back it out 1 turn.

5.8.128 Thread measuring rod T1050261-1 into end of tie bolt and set up dial indicator.

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5.8.129 Using hand pump extend ram to takeup clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against turbine, 1st stage and aligned freely inside turbine 2nd stage.

5.8.130 Using hand pump stretch tie bolt until pressure is at cylinder pressure in step 5.8.110 or 5.8.117 whichever is higher.
NOTE: DO NOT EXCEED 3700 PSI.

5.8.131 Back off nut 1139386-1 by using wrench T1050260-1.

5.8.132 Remove dial indicator and unscrew measuring rod T1050261-1.

5.8.133 Unscrew pull sleeve T1050258-1 and remove bolt stretcher.

5.8.134 Remove nut 1139386-1 and lockwasher 1139387-1.

5.8.135 Grind lockwasher 1139387-1 to $(R_1) \pm .0002$ (from surface indicated on drawing) and mark per ASD5215C with "MOD" following existing P/N and actual (R_1) .

Record actual (R_1) _____ in.

Record S/N _____ in.

5.8.136 Install modified lockwasher 1139387-1 (ref. step 5.8.135) and nut finger tight. Do not bend lockwasher tabs.

5.8.137 Set up bolt stretcher on crane at turbine location.

5.8.138 Insert free end of thrust sleeve T1050259-1 into second stage turbine.

5.8.139 Install spacer T1050262-1 into pull sleeve T1050258 and thread onto end of tiebolt finger tight and then back it out 1 turn.

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- 5.8.140 Thread measuring rod T1050261-I into end of tiebolt and set up dial indicator.
- 5.8.141 Using hand pump, extend ram to take up clearance between ram and collar on pull sleeve. Ensure that thrust sleeve is seated squarely against first stage turbine and aligned freely inside second stage turbine.
- 5.8.142 Using hand pump, stretch tiebolt until pressure gage reads 2750 psi.
- 5.8.143 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve T1050259 by hand).
- 5.8.144 Record dial indicator reading, $J =$ _____ in.
- 5.8.145 Compute and record $K = J + C + .018 =$ _____ in.
- 5.8.146 Using hand pump, stretch bolt until indicator reading is K.
Record actual $K =$ _____ in.
Record cylinder pressure = _____ psi.
NOTE: DO NOT EXCEED 3700 PSI.
- 5.8.147 Turn nut 1139386-I up by hand using wrench T1050260-I.
- 5.8.148 Release oil pressure until clearance between ram and collar on pull sleeve is zero. (Verify by being just able to rotate thrust sleeve by hand.)
- 5.8.149 Record dial indicator reading, $L =$ _____ in.
- 5.8.150 Compute and record $M = L - K =$ _____ in.
- 5.8.151 If $M = .018 \pm .001$ go to step 5.8.158. If not, continue with step 5.8.152.

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5.8.152 Compute and record $.018 - N =$ _____ in.

5.8.153 Using hand pump, stretch bolt until indicator reading is

$K_1 = K + .018 - N =$ _____ in.

(Nut may have to be loosened.)

Record actual $L_1 =$ _____ in.

Record cylinder pressure _____ psi.

NOTE: DO NOT EXCEED 3700 PSI.

5.8.154 Turn nut by hand using wrench.

5.8.155 Release oil pressure until clearance between ram and collar on pull sleeve is zero. Verify as in step 5.8.143

5.8.156 Record dial indicator reading $L_1 =$ _____ in.

5.8.157 Compute and record $M_1 = L_1 - J =$ _____ in.

If $M_1 = .018 + .001$ go to Step 5.8.158. If not repeat Steps 5.8.151 through 5.8.157 until it is. Record all values each time.

5.8.158 Remove dial indicator and unscrew measuring rod T1050261-1.

5.8.159 Unscrew pull sleeve T1050258-1 and remove bolt stretcher. Do not bend lockwasher tabs.

5.8.160 Measure and record (V) required position of nut aft to turbine inlet housing ref. Step 5.8.123.

Record actual (V) _____ in.

5.8.161 If (V) is not $.040 \pm .005$ repeat Steps 5.8.124 to 5.8.160 until it is.

5.8.162 When 5.8.161 is achieved bend tabs on lockwasher.

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5.8.163 Install gear rotor crank 1139417-1, crank rotor shaft 1139418-1, locknut rotor crank 1139419-1, lockwasher rotor crank 1139420-1 in the disengaged position into turbine exhaust housing 1139397-1.

5.8.164 Install internal instrumentation into and shield turbine exhaust housing 1139474-1 on to turbine exhaust housing 1139397-1.

5.8.165 Grind shim 1139407-2 to $(T_1) \pm .0002$ thick and mark per ASD5215C with "MOD" following existing P/N and actual (T_1) . Thickness to be determined by cognizant engineer.

Record actual (T_1) _____ in.

Record serial number _____.

5.8.166 Install modified shim (ref. step 5.8.165) onto turbine exhaust housing and seal 1139429-3 onto turbine inlet housing.

5.8.167 Warm area of female pilot diameter of flange joint on turbine exhaust housing to 175°F and install onto turbine inlet housing with associated hardware.

5.8.168 After parts have returned to room temperature, engage rotor crank. Use T1050214-1 to retain crank in engaged position. Using wrench T1050272-1, turn rotor crank by hand to determine that rotor is turning free.

5.8.169 After achieving 5.8.168, disengage rotor crank, install locknut 1139419 and lockwasher 1139420-1 and bend lockwasher tabs.

5.8.170 Install rotor crank cap 1139444-1 and seal 1139428-1 with associated hardware.

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5.9 FINAL PUSH - PULL TEST

- 5.9.1 Install hydrostatic test cover TI050220-I and seal onto turbine exhaust housing with associated hardware.
- 5.9.2 All ports to be plugged with appropriate plugs. For plug information see appropriate housing detail drawings. Hydrostatic proof test.
- 5.9.3 Measure and record breakaway and running torque on shaft at room temperature.
 Breakaway torque = _____.
 Running torque = _____.
- 5.9.4 Install push - pull fixture TI050266-I step I onto front end of assembly (inducer housing). Rotate assembly to the vertically up position.
- 5.9.5 Check for indications of shaft rubbing (such as noise or regions where shaft feels hard to turn) by rotating the shaft.
- 5.9.6 Push the shaft forward with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.9.5.
- 5.9.7 Pull the shaft aft with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.9.5.
- 5.9.8 Perform push-pull test by loading the shaft as indicated in table.
 NOTE: If any target load is exceeded, do not reverse the loading direction to achieve the target load. Record the actual load and shaft movement at each target load in table.

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FORWARD DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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FOWARD DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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- 5.9.9 Measure and record the deadband travel by pushing and pulling the shaft through the region of nearly zero load. The deadband travel is the total motion measured while the load is approximately constant and nearly zero.

Deadband travel _____ in.

- 5.9.10 Fill assembly with LN₂ thru turbine inlet and pump discharge with suitable vents. Note stabilized condition by location of frost line on pipe.

- 5.9.11 Check for indication of shaft rubbing (such as noise or regions where shaft feels hard to turn) by rotating the shaft.

- 5.9.12 Push the shaft forward with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.9.11.

- 5.9.13 Pull the shaft aft with loads from 100 to 1500 pounds in 100 pound increments. At each load value, repeat step 5.9.11.

- 5.9.14 Perform push-pull test by loading the shaft as indicated in table. Note: If any target load is exceeded, do not reverse the loading direction to achieve the target load. Record the actual load and shaft movement at each target load in table.

- 5.9.15 Measure and record the deadband travel by pushing and pulling the shaft through the region of nearly zero load. The deadband travel is the total motion measured while the load is approximately constant and nearly zero.

Deadband travel _____ in.

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FOWARD DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION		
TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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DATE

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FOWARD DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
+100		
+200		
+300		
+400		
+500		
+600		
+700		
+800		
+900		
+1000		
+1100		
+1200		
+1300		
+1400		
+1500		
+1400		
+1300		
+1200		
+1100		
+1000		
+900		
+800		
+700		
+600		
+500		
+400		
+300		
+200		
+100		
0		

AFT DIRECTION

TARGET LOAD	ACTUAL LOAD	DEFLECTION
0		
-100		
-200		
-300		
-400		
-500		
-600		
-700		
-800		
-900		
-1000		
-1100		
-1200		
-1300		
-1400		
-1500		
-1400		
-1300		
-1200		
-1100		
-1000		
-900		
-800		
-700		
-600		
-500		
-400		
-300		
-200		
-100		
0

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5.9.16 Disconnect LN₂ supply and drain assembly.

5.9.17 Remove any dummy plug from ports and install all external instrumentation.

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5.10 LEAK CHECK

5.10.1 When assembly has reached room temperature, install covers on flanges of pump housing, turbine inlet housing, and turbine exhaust housing with suitable vents.

5.10.2 Hook up a 50 psig GN₂ supply.

5.10.3 Verify that all the turbopump assembly bosses are plugged.

5.10.4 With the assembly pressurized to 50 psig with GN₂, leak check all joints with soap solution.

5.10.5 Verify that no visual leaks exist.

5.10.6 Maintain a 5 psig dry filtered GN₂ purge on the assembly until further notification.

5.10.7 Clear build-up log book to date and disposition all inspection reports.

10 April 1972

SUBJECT

PARTS LIST
TURBOPUMP ASSEMBLY (DEVELOPMENT)
1139350

BY

P. PARE' / T. PETERSEN

CHK BY

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DRAWING NUMBER

TITLE

1139350	TPA (TOP ASSEMBLY DRAWING)
1139351	TURBINE ROTOR, FIRST STAGE - ROUGH MACHINE
1139352	RUB RING - AFT, BALANCE PISTON PUMP (MIN. DIA)
1139353	RUB RING, AFT, BALANCE PISTON, PUMP (MEAN DIA)
1139354	FORGING, BAFFLE - TURBINE INLET HOUSING
1139355	TURBINE STATOR, SECOND STAGE
1139356	TURBINE STATOR, FIRST STAGE
1139357	STUD, ROTOR, TURBINE
1139358	INDUCER, PUMP
1139359	IMPELLER, FIRST STAGE, PUMP
1139360	IMPELLER, SECOND STAGE, PUMP
1139361	TIE BOLT, ROTOR, TURBOPUMP
1139362	STUD, INDUCER, PUMP
1139363	SPACER, BEARING, TURBOPUMP (SEMI FINISH)
1139364	SPACER, SECOND STAGE
1139365	SPACER, FIRST STAGE
1139366	KEY STATOR - TURBINE
1139367	RING, BAYONET, AFT CARTRIDGE PUMP (SEMI FINISH)
1139368	TURBINE ROTOR, SECOND STAGE - ROUGH MACHINED
1139383	SPINNER, PUMP, INDUCER
1139384	NUT, TIE BOLT
1139385	LOCKWASHER, TIE BOLT NUT - FORWARD
1139386	NUT, TIE BOLT, AFT - TURBOPUMP
1139387	LOCKWASHER, TIE BOLT NUT - AFT
1139388	LOCKNUT, IMPELLER - SECOND STAGE
1139389	LOCKWASHER, IMPELLER, SECOND STAGE
1139390	HOUSING, INDUCER - TURBOPUMP
1139391	LINER, INDUCER HOUSING
1139392	LINER, SPOKED, INDUCER HOUSING
1139393	SHROUD, INDUCER, SPLIT
1139394	PUMP HOUSING, TURBOPUMP
1139395	HOUSING, AFT BEARING, TURBOPUMP
1139396	MANIFOLD, TURBINE INLET, TURBOPUMP

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1139397	TURBINE EXHAUST HOUSING, TURBOPUMP
1139398	ROTOR, MACHINING ASSEMBLY
1139399	ROTOR, LOW SPEED BALANCE ASSEMBLY
1139400	ROTOR, HIGH SPEED BALANCE ASSEMBLY
1139401	CARTRIDGE, FORWARD BEARING- TURBOPUMP
1139402	CARTRIDGE, AFT BEARING - TURBOPUMP
1139403	HOUSING ALIGNMENT ASSEMBLY - TURBOPUMP
1139404	SHIM, TRANSDUCER - TURBOPUMP
1139405	SHIM, RUB RING - BALANCE PISTON, PUMP
1139406	RETAINER, AFT RUB RING BALANCE PISTON, PUMP
1139407	SHIM, TPA
1139408	SHIELD, OUTER - AFT BEARING SUPPORT, TURBOPUMP
1139409	SHIELD, INNER, AFT BEARING HOUSING, TURBOPUMP
1139410	RETAINER, FORWARD RUB RING - BALANCE PISTON, PUMP
1139411	LABYRINTH, AFT BEARING - TURBOPUMP
1139412	LABYRINTH, SECOND STAGE IMPELLER - TURBOPUMP
1139413	LABYRINTH, FORWARD BEARING, TURBOPUMP
1139414	RUB RING, FORWARD BALANCE PISTON - PUMP (SEMI-FINISH)
1139415	TUBE ASSEMBLY, FORWARD BEARING LUBE - PUMP
1139416	TUBE ASSEMBLY, AFT BEARING LUBE - PUMP
1139417	GEAR, ROTOR CRANK - PUMP
1139418	SHAFT, ROTOR CRANK - PUMP
1139419	LOCKNUT, ROTOR CRANK - PUMP
1139420	LOCKWASHER, ROTOR CRANK - PUMP
1139421	TRANSDUCER, FORWARD BEARING - PUMP
1139422	TRANSDUCER, SPINNER - PUMP
1139423	TRANSDUCER, RPM - PUMP
1139424	TRANSDUCER, DISPLACEMENT - PUMP
1139425	LOCKNUT, FORWARD BEARING TRANSDUCER - PUMP
1139426	TRANSDUCER, RESISTANCE TEMPERATURE, FLUID
1139427	TRANSDUCER, RESISTANCE TEMPERATURE, FLUID
1139428	SEAL, FLANGE, TURBOPUMP
1139429	SEAL, HOUSING, TURBOPUMP

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1139430	CAP, RETAINER, ROTOR, TURBOPUMP
1139431	SEAL, FORWARD, FIRST STAGE STATOR, TURBOPUMP
1139432	SEAL, AFT, FIRST STAGE STATOR, TURBOPUMP
1139433	LOCKNUT - INDUCER HOUSING LINER, TURBOPUMP
1139434	LOCKWASHER - INDUCER HOUSING LINER, TURBOPUMP
1139435	RETAINING RING, INDUCER SHROUD, PUMP
1139436	FAIRING RING, PUMP HOUSING CROSSOVER - PUMP
1139437	INSERT, PRELOAD, SECOND STAGE IMPELLER
1139438	TRUNNION, TIEDOWN - TURBOPUMP
1139439	TRUNNION, FLOATING - TURBOPUMP
1139440	MANIFOLD, BALANCE PISTON DRAIN - PUMP
1139441	PUMP ROTOR SUBASSEMBLY - PUMP
1139442	TURBINE ROTOR SUBASSEMBLY, PUMP
1139443	SPINNER (SLAVE) ROTOR - PUMP
1139444	CAP, ROTOR CRANK - PUMP
1139449	SHIM, BRACKET, TPA FACILITY MOUNT
1139450	BRACKET SUBASSEMBLY - TPA FACILITY MOUNT
1139451	BRACKET - TPA FACILITY MOUNT
1139452	NUT, TRUNNION - TPA FACILITY MOUNT
1139453	NUT, BRACKET - TPA FACILITY MOUNT
1139454	BUSHING, BRACKET - TPA FACILITY MOUNT
1139455	TRANSDUCER, RESISTANCE TEMPERATURE FLUID
1139456	TRANSDUCER, RESISTANCE TEMPERATURE FLUID
1139457	FILTER, BEARING LUBE - PUMP
1139458	ORIFICE, BEARING LUBE - PUMP
1139460	TRUNNION INSTALLATION KIT, TIE DOWN - TPA FACILITY MOUNT
1139461	TRUNNION INSTALLATION KIT, FLOATING - TPA FACILITY MOUNT
1139462	TRANSDUCER, RESISTANCE TEMPERATURE, FLUID
1139463	WASHER, SPINNER, PUMP
1139464	BOLT, SPINNER, PUMP
1139465	RUB RING, AFT - BALANCE PISTON, PUMP (MAX DIAMETER)
1139468	CONNECTOR, 4 PIN - TPA
1139469	CONNECTOR, 8 PIN - TPA
1139470	IMPELLER, SECOND STAGE, PUMP

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1139471	ADAPTER, CONNECTOR - TPA
1139472	LABYRINTH, FORWARD BEARING , OUTBOARD - TPA
1139473	SHIM, BAYONET
1139474	SHIELD, TURBINE EXHAUST HOUSING - TPA
1139475	TRANSDUCER, RESISTANCE TEMPERATURE, SKIN
1139476	FITTING, SWAGE PRESS FITTING - TPA
1139477	PRESSURE FITTING (TUBE TYPE) - TPA
1139478	PRESSURE FITTING - TPA
1139479	SHIM, AFT LABYRINTH - TPA
1139480	LOCKWASHER, TRANSDUCER - TPA
1139481	SHIM, SECOND STAGE IMPELLER - TPA
1139482	PRESSURE FITTING, TURBINE INLET GUIDE VANE - TPA
1139483	PLUG, PRESSURE FITTING - TURBINE INLET FLANGE
1139484	COVER - 4 PIN CONNECTOR
1139485	RETAINER, RESISTANCE TEMPERATURE TRANSDUCER,SKIN
1139487	SHIM, TRANSDUCER PROBE - INDUCER HOUSING
1139488	SPACER, RESISTANCE TEMPERATURE TRANSDUCER,SKIN
1139489	RETAINER, RESISTANCE TEMPERATURE TRANSDUCER,SKIN
1139490	RETAINER, RESISTANCE TEMPERATURE TRANSDUCER, SKIN
1139491	WASHER, KEY - SHIELD OUTER AND TURBINE EXHAUST
1139494	WASHER, KEY - SHIELD, INNER
1139495	WASHER, COUNTERSUNK
1139496	BOLT, REDUCED HEAD
1139517	RETAINING RING, QUILL SHAFT - ROTORDYNAMICS
1139519	DOWEL PIN (SPECIAL) - ROTORDYNAMICS
1139520	STOP PIN, MOUNT - ROTORDYNAMICS
1139521	CARTRIDGE, AFT BEARING - ROTORDYNAMICS
1139522	CARTRIDGE, FORWARD BEARING - ROTORDYNAMICS
1139523	ADAPTER, GEAR BOX - ROTORDYNAMICS
1139524	ADAPTER, AFT DRIVE - ROTORDYNAMICS
1139525	ADAPTER, FORWARD BEARING, CLAMP, ROTORDYNAMICS
1139526	ADAPTER, AFT BEARING, CLAMP - ROTORDYNAMICS
1139529	THERMOCOUPLE ASSEMBLY, MOUNT - ROTORDYNAMICS

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1139530	TRANSDUCER, PROXIMITY - ROTORDYNAMICS
1139531	PROBE, BEARING LUBE, MOUNT, ROTORDYNAMICS
1139532	SHIM, AFT, MOUNT - ROTORDYNAMICS
1139533	SHIM, FORWARD, MOUNT - ROTORDYNAMICS
1139534	DOWEL (SPECIAL) - ROTORDYNAMICS
1139535	ALIGNMENT ASSEMBLY - ROTORDYNAMICS
1139536	ADAPTOR, FIRST STAGE TURBINE, MOUNT - ROTORDYNAMICS
1139537	SUPPORT, SECOND STAGE TURBINE, MOUNT - ROTORDYNAMICS
1139538	SUPPORT, SECOND STAGE IMPELLER, MOUNT-ROTORDYNAMICS
1139539	SUPPORT, INDUCER END, MOUNT - ROTORDYNAMICS
1139540	CROSS BAR, TOP, MOUNT - ROTORDYNAMICS
1139541	CROSS BAR, REAR, MOUNT - ROTORDYNAMICS
1139542	CROSS BAR, FRONT, MOUNT - ROTORDYNAMICS
1139543	BASE PLATE, MOUNT - ROTORDYNAMICS
1139544	PEDESTAL, AFT, MOUNT - ROTORDYNAMICS
1139545	PEDESTAL, FORWARD, MOUNT - ROTORDYNAMICS
1139546	QUILL SHAFT - ROTORDYNAMICS
1139547	BASE - ROTORDYNAMICS
1139549	ROTORDYNAMICS FACILITY KIT
1139550	ROTORDYNAMICS MOUNT KIT

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PARTS LIST

TOOLING FOR TURBOPUMP ASSEMBLY

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TI050200	ARBOR, SECOND STAGE IMPELLER (MACHINE AND SPIN)
TI050201	ARBOR, SPINNER (MACHINE AND BALANCING)
TI050202	SLEEVE, ARBOR, SECOND STAGE IMPELLER (MACHINE & SPIN)
TI050203	NUT, ARBOR, SECOND STAGE IMPELLER (MACHINE AND SPIN)
TI050204	ARBOR, LOCKNUT, SECOND STAGE IMPELLER
TI050205	ARBOR, ROTOR SUBASSEMBLY (SPINNING)
TI050206	PIN, ALIGNING, PUMP ROTOR SUBASSEMBLY
TI050207	SPACER, ROTOR MACHINING
TI050208	CLAMPING TOOL, SECOND STAGE IMPELLER
TI050209	HOLLOW WRENCH ASSEMBLY, TURBINE ROTORS
TI050210	
TI050211	ARBOR, FORWARD ADAPTER (MACHINE) (ROTOR DYNAMICS)
TI050212	FIXTURE, ALIGNMENT, PUMP ROTOR SUBASSEMBLY
TI050213	CRADLE, ASSEMBLY, ROTOR HANDLING, TPA
TI050214	RETAINER, COLLAR, CRANK, TPA
TI050215	LIFTING COVER, TPA
TI050216	PIN, ALIGNING, TURBINE ROTOR SUBASSEMBLY
TI050217	FIXTURE, HYDROSTATIC TEST, TURBINE INLET HOUSING
TI050218	WRENCH, TURBINE ROTOR - TIEBOLT
TI050219	FIXTURE, HYDROSTATIC TEST, AFT BEARING HOUSING
TI050220	FIXTURE, HYDROSTATIC TEST, TURBINE EXHAUST HOUSING
TI050221	FIXTURE, HYDROSTATIC TEST, PUMP HOUSING
TI050222	INSTALLATION, FIXTURE, SECOND STAGE IMPELLER INSERT
TI050223	CLAMP, DUMMY - HOUSING ALIGNMENT ASSEMBLY
TI050224	PLUG, HYDROSTATIC TEST
TI050225	CALIBRATION AND INSTALLATION FIXTURE, BEARING PACKAGE
TI050226	PUSH PULL FIXTURE, ROTOR TPA
TI050227	INSTALLATION FIXTURE, INDUCER SHROUD
TI050228	PULLER, INDUCER, HOUSING LINER
TI050229	PULLER, CARTRIDGE, (BAYONET TYPE)
TI050230	PULLER, INBOARD BEARING - OUTER RACE AND BALLS
TI050231	PULLER, TURBINE STATOR AND ROTOR UNIT
TI050232	PULLER, PUMP ROTOR SUBASSEMBLY

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TI050233	ARBOR PRESS FIXTURE, LOW SPEED BALANCING - BEARING AND SPACER REMOVAL
TI050234	HOLDING FIXTURE, ROTOR
TI050235	SPANNER WRENCH, INDUCER LINER NUT
TI050236	SPANNER WRENCH, ROTOR CRANK NUT
TI050237	SPANNER WRENCH, BEARING LUBE ORIFICE
TI050238	SPANNER WRENCH, FORWARD TRANSDUCER NUT
TI050239	PULLER, ROTOR RETAINING CAPS
TI050240	SPANNER WRENCH, TRUNNION NUT
TI050241	SPANNER WRENCH, TRUNNION BRACKET NUT
TI050242	PULLER, SPINNER - KIT
TI050243	SPANNER WRENCH, BALANCING PISTON BAYONET
TI050244	PULLER, HIGH SPEED BALANCE ROTOR ADAPTERS
TI050245	ARBOR PRESS FIXTURE
TI050246	ROD, ROTOR FRICTION
TI050247	
TI050248	LIFTING COVER, PUMP HOUSING (TPA TO ASSEMBLY STAND)
TI050249	INSTALLATION TOOL, RETAINING CAP
TI050250	BUILD STAND, TPA
TI050251	FRAME ASSEMBLY, BUILD STAND - TPA
TI050252	FRAME, BUILD STAND WELDMENT
TI050253	INSTALLATION TOOL, ROTOR AND STATOR SUBASSEMBLY
TI050254	WRENCH, RETAINING - TIEBOLT, FORWARD
TI050255	WRENCH, RETAINING - TIEBOLT, AFT
TI050256	COVER PLATE, PUSH PULL, LH ₂
TI050257	
TI050258	SLEEVE, PULL - BOLT STRETCHER
TI050259	SLEEVE, THRUST - BOLT STRETCHER
TI050260	SOCKET WRENCH - BOLT STRETCHER
TI050261	ROD, MEASURING - BOLT STRETCHER
TI050262	SPACER, PULLER SLEEVE - BOLT STRETCHER
TI050263	BOLT STRETCHER ASSEMBLY
TI050264	BLOCK CALIBRATION

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TI050265	PULLER, RETAINING CAP, AFT
TI050266	SPANNER WRENCH, FILTER CARTRIDGE
TI050267	PULLER, INBOARD BEARING - INNER RACE
TI050268	KIT, PULLER - FIRST / SECOND STAGE
TI050269	PULLER, STATOR AND SPACER UNIT - TPA
TI050270	FIXTURE, RETAINER - IMPELLER INSERT
TI050271	GAGE, RING - INSERT, SECOND STAGE IMPELLER
TI050272	TORQUE WRENCH, CRANK