SUBSYSTEM:THRUST VECTOR CONTROL

ITEM NAME: Hydraulic Pump

PART NO.: 10201-0051-801, -802(Alt.)
includes:
Fittings, Connector:
10209-0038-801
10209-0077-801
10209-0036-801
O-Rings:
Type M83248/1
Plug, Seepage:
MS24391 J4L

FM CODE: A02

ITEM CODE: 20-01-29

REVISION: Basic

CRITICALITY CATEGORY: 1R

REACTION TIME: Seconds

NO. REQUIRED: 2

DATE: March 1, 2002

CRITICAL PHASES: Boost

SUPERCEDES: March 1, 2001

FMEA PAGE NO.:A-103

ANALYST: B. Snook/ S. Finnegan

CN 044

SHEET 1 OF 5

APPROVED: S. Parvathaneni

FAILURE MODE AND CAUSES: Rotating Group fails to operate (Systems A and B) caused by:

- o Contamination
- o Piston and shoe galling
- o Cylinder/piston seizure
- o Bearing failure/seizure
- o Port plate scoring
- o Thrust washer seizure
- o Failure of plate and washer retainer/and hanger breakage
- o Shoe Retaining Plate Breakage
- o Shaft Breakage
- o Spline failure
- o Wear plate scoring
- o Manufacturing defect
- o Thrust pad breakage
- o Retainer nut failure

FAILURE EFFECT SUMMARY: Loss of TVC will lead to loss of mission, vehicle and crew. One success path remains after the first failure. Operation is not affected until both paths are lost.

REDUNDANCY SCREENS AND MEASUREMENTS:

1. Pass - All units are subject to ABEX ATP TP-675.

2. Pass - Hydraulic pressure measurements B58P1303C and B58P1304C.

3. Fail - Contamination

RATIONALE FOR RETENTION:

A. DESIGN

- The Hydraulic Pump is designed and qualified in accordance with end item specification 10SPC-0053. (All failure causes)
- Piston is 52100 alloy steel heat treated to Rockwell hardness of C58-62 (310-350 KSI). (Cylinder/Piston Seizure and Manufacturing Defect, Such As Improper Heat Treating)
- Retainer nut is 4140 alloy steel heat treated to a Rockwell hardness of C28-32. (Retainer Nut Failure)
- Retainer nut torque is per drawing specification. (Retainer Nut Failure)
- Shoe is 4140 alloy steel heat treated to Rockwell C30-35 and bronze plated on the base for wear resistance. Oil passages through the piston and shoe assembly provide lubrication. (Piston/Shoe Galling)
- Cylinder and thrust washer are CDA-673 bronze alloy to reduce potential seizure. (Cylinder/Piston Seizure, Thrust Washer Failure)
- Bearing race and rollers are M-50 tool steel heat treated to Rockwell hardness of C60-64 (340-375 KSI). (Bearing Failure/Seizure and Manufacturing Defect, Such as Improper Heat Treating)
- Bearing cage material is bronze. (Bearing Failure/Seizure)
- Fluid procurement is controlled per SE-S-0073. (Contamination)
- Hanger is 4340 alloy steel, heat treated to Rockwell hardness C28-32 (135-150 KSI). (Failure of Plate and Washer Retainer/and Hanger Breakage)
- Plate and washer retainer are 4620 alloy steel, condition of C-4, heat treated to a case hardness of C56-62 (290-350 KSI) and a core hardness of C34-48 (160-235 KSI). (Failure of Plate and Washer Retainer/and Hanger Breakage)
- Wear Plate is M-50 tool steel heat treated to a Rockwell hardness of C58-64. (Wear Plate Scoring)
- Bearing basic static capacity is 13,700 lbs. Basic dynamic capacity is 14, 600 lbs. (Bearing Plate Failure/Seizure)
- Port plate is 52100 alloy steel heat treated to Rockwell hardness of C58-62. (Port Plate Scoring and Manufacturing Defect, Such as Improper Heat Treat)
- Cylinder surface that mates to port plate is silver plated to prevent scoring or galling. (Port Plate Scoring)

- Shoe retaining plate is 135M nitralloy with a core hardness of C26-32 and is case hardened to C60 (min) to a depth of .011-.018 inch. (Shoe Retaining Plate Breakage)

- Both internal and external shafts are 17-4PH Cres heat treated to a Rockwell hardness of C36-40. (Shaft Breakage and Manufacturing Defect, Such as Improper Heat Treat)

- Shaft is designed to shear at 5600 $\pm$ 200 in-lbs. Shear by test occurred at 5620 in-lbs. Normal operating torque is 2200 in-lbs at full flow and 3200 psig output pressure. (Shaft Breakage)

- External drive shaft and internal drive shaft splines are 17-4PH CRES heat treated to a Rockwell hardness of C36-40 (168-185 KSI). Bushing spline is alloy steel (4140) heat treated to a Rockwell hardness of C26-32 (128-150 KSI). (Spline Failure)
- Heat treating is governed by MIL-H-6875 and verified by source inspection plan (SIP) 1258. (Manufacturing Defect, Such as Improper Heat Treating)

- Qualification testing verified design requirements as reported in ABEX Qualification Test Report AER-729. (All Failure Causes)

- Thrust pad is M-50 tool steel heat treated to a Rockwell hardness of C58-64 for wear resistance and dry film lubricated. (Thrust Pad Breakage)

B. TESTING

- Acceptance test is performed per ABEX ATP TP-675 on each flight item. This includes visual examination, electrodepressurization valve test, break in run, overspeed test to 4755 rpm, proof pressure test, functional test which includes leakage test for no external leakage except one drop in 5 minutes at shaft seal, depressurized start, pressurization, and transient response not to exceed 125 ms. (All Failure Causes)

- During refurbishment, the pump is reworked per 10SPC-0131 and tested per ATP TP-675 to ensure proper operations. (All Failure Causes)

- Hydraulic fluid is verified for cleanliness and composition (purity and particulate count) prior to introduction to on-board hydraulic circuits per 10REQ-0021, para. 2.3.2.6. (Contamination)

- Effluent hydraulic fluid is verified for moisture content and cleanliness (water content and particulate count) from the rock actuator, the tilt reservoir, the rock reservoir and the tilt actuator per 10REQ-0021, para. 2.3.12.3. (Contamination)

- Proper operation of the rotating group is verified by test during Hotfire per 10REQ-0021, para. 2.3.16. (All Failure Causes)

- Hydraulic fluid (effluent) is verified for moisture per OMRSD File V, Vol. 1 Requirement Number B42HP0.011 and B42HP0.070. (Contamination)

- Hydraulic fluid is verified for cleanliness and composition (purity and particulate count) prior to introduction to on-board hydraulic circuits during prelaunch operations per OMRSD File V, Vol. 1 Requirement Number B42HP0.010. (Contamination)

- Helium is verified for cleanliness and composition (purity and particulate count) prior to introduction to on-board circuits per 10REQ-0021, para. 2.3.2.5.

C. INSPECTION

VENDOR RELATED INSPECTIONS

- Nondestructive Evaluation (NDE) is performed on subassemblies by USA SRBE PQAR per SIP 1258. (Defective or Damaged Sealing Surface)

- Verification of disassembled parts is performed by USA SRBE PQAR per SIP 1258. (All Failure Causes)

- Witnessing of acceptance testing is performed by USA SRBE PQAR per SIP 1258. (All Failure Causes)

- Verification that Parker Abex has performed and accepted all required Hydraulic Pump refurbishment and inspections per TP-1210 by USA SRBE PQAR per SIP 1258. (All Failure Causes) CN 044

- Critical Processes/Inspections:

  - Nitride per MIL-S-6090
  - Heat treat per MIL-H-6875
  - Penetrant inspection per ASTM E1417
  - Silver plating per PTS-SP-001
  - Heat treat (retainer nut) per MIL-H-6875
  - Magnetic particle inspection (retainer nut) per ASTM-E-1444.

KSC RELATED INSPECTIONS

- Hydraulic fluid cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board hydraulic circuits per 10REQ-0021, para. 2.3.2.6. (Contamination)

- Helium cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board circuits per 10REQ-0021, para. 2.3.2.5. (Contamination)

- o The moisture content and cleanliness (water content and particulate count) of the effluent hydraulic fluid from the rock actuator, the tilt reservoir, the rock reservoir and the tilt actuator are verified per 10REQ-0021, para. 2.3.12.3. (Contamination)

- o Hydraulic fluid cleanliness and composition (purity and particulate count) are verified prior to introduction to on-board Hydraulic circuits during prelaunch operations per OMRSD File V, Vol. 1 Requirement Number B42HP0.010. (Contamination)

- o Verification of hydraulic fluid (effluent) sample is performed for moisture and dissolved air content per OMRSD File V, Vol. 1 Requirement Number B42HP0.011 and B42HPO.070. (Contamination)

- o Pump operation is verified during hotfire operations per 10REQ-0021, para. 2.3.16.. (All Failure Causes)

- o Pump operation is monitored during Final Countdown from T-15 Sec. to T-7 Sec. by the automatic GLS system per OMRSD File II, Vol. 1, Requirement Number S00FR0.070. (All Failure Causes)

D. FAILURE HISTORY

- o Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- o Not applicable to this failure mode.