

SRB CRITICAL ITEMS LIST

SUBSYSTEM: THRUST VECTOR CONTROL

ITEM NAME: APU Gearbox

PART NO.: 740413 includes: FM CODE: A02
716604 (Lube Oil Pump)
5903457 (Oil Filter)
717644A (Relief Valve)
732186 (Gearbox Equalization Valve)
5903967 (O-ring)
5905446 (O-ring)
57399 (O-ring)
M83248/1 (O-ring)
5904000 Lube Oil Indicator Internal
Gearbox Accumulator, Gears and Shafts
Covered under P/N 740413

ITEM CODE: 20-01-28 REVISION: Basic

CRITICALITY CATEGORY: 1R REACTION TIME: Seconds

NO. REQUIRED: 2 DATE: March 1, 2001

CRITICAL PHASES: Boost SUPERCEDES: March 31, 1997

FMEA PAGE NO.: A-74 ANALYST: R. Imre/ S. Parvathaneni

SHEET 1 OF 5 APPROVED: S. Parvathaneni

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FAILURE MODE AND CAUSES: No power output (System A and B) caused by:

- o Contaminated Lube oil/Loss of lubrication
- o Fractured gear or gear teeth
- o Shaft fracture
- o Material defect
- o Manufacturing defect
- o Bearing failure

FAILURE EFFECT SUMMARY: Loss of TVC will lead to vehicle breakup and 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 - Function is verified by Sundstrand ATP TS 2409 during turnaround and refurbishment.
- 2) Pass - Hydraulic pressure measurements B58P1303C, B58P1304C.
- 3) Fail - Contamination.

RATIONALE FOR RETENTION:

A. DESIGN

- o The APU Gearbox is designed and qualified in accordance with end item specification 10SPC-0050. (All Failure Causes)
- o Lube oil is filtered through a 35 micron filter at the pump discharge. (Contaminated Lube Oil/Loss of Lubrication)
- o Lube oil is supplied per MIL-L-23699 or MIL-PRF-23699. (Lube Oil Contamination)
- o Portion of the oil is bypassed in the filter through 10 EA .020 inch dia. holes drilled in the cartridge. (Contamination)
- o Gear (idler) and gearshafts material is 9310 steel, heat treated to a hardness of C42 (idler and output) maximum (non-carbonized areas) and C58-62 (carburized gear teeth areas). (Fractured Gear or Gear Tooth, Shaft Failure, Material or Manufacturing Defect)
- o Gear (High Speed Assembly) material is H-11 steel, heat treated to a hardness of 92-95R 15/N (Nitrided, Gear Teeth Areas). (Fractured Gear or Gear Tooth, Shaft Failure)
- o Gears and gear shaft are dynamically balanced to .008 in-oz per Sundstrand drawing 716615. (Shaft Failure)
- o APU surfaces exposed to lube oil are cleaned to Level 300 of SN-C-0005. (Contamination)
- o Materials are selected per MSFC-SPEC-522A. (Fractured Gear or Gear Tooth, Shaft Failure, Material or Manufacturing Defect, Bearing Failure)
- o Roller bearing size variation is limited to .000025 inch. Rollers, race and ball bearings are Rockwell hardness C60-65, AMS6490 steel. (Material or Manufacturing Defect, Bearing Failure)
- o Fluid procurement is controlled per SE-S-0073. (Contamination)
- o Qualification testing verified design requirements as reported in Sundstrand APU Qualification Test Report AER 1539-6 Rev. B. (All Failure Causes)

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B. TESTING

- o Acceptance testing is performed per Sundstrand ATP TS 2409 on all new flight units. This includes a GN2 spin and hotfire functional tests with leak checks both before and after and gearbox lube oil check for contamination. (All Failure Causes)

- o During refurbishment and prior to reuse, the gearbox assembly is reworked and inspected with the same assembly verifications and ATP as new units. (All Failure Causes)
- o Lube oil sampling for cleanliness and composition (purity and particulate count) verification is performed prior to loading per 10REQ-0021, para. 2.3.2.3. (Contamination)
- o Manufacturing is monitored with Source Inspection Plan SIP 1128 by USA SRBE PQAR. (All Failure Causes)
- o Functional test is performed during hotfire operations per 10REQ-0021, paras. 2.3.11, 2.3.15 and 2.3.16 respectively for: (Fractured Gear or Gear Tooth, Shaft Failure Bearing Failure)
 - Low speed GN2 spin
 - High speed GN2 spin
 - Hotfire
- o Gearbox lube oil post hotfire sampling is performed per 10REQ-0021, para. 2.3.16.6. (Contamination)
- o Gearbox is flushed with clean oil, purged and pressurized with GN2 after hotfire per 10REQ-0021, para. 2.3.16.5.e. (Contamination)

C. INSPECTION

VENDOR RELATED INSPECTIONS

- o O-ring and lap seal face inspections are verified per SIP 1128 by USA SRBE-PQAR. (Material or Manufacturing Defect)
- o Leak check of gearbox assembly is verified per SIP 1128 by vendor and USA SRBE. (Material or Manufacturing Defect)
- o Verification of seal face flatness is performed per SIP 1128 by vendor and USA SRBE. (Material or Manufacturing Defect)
- o Verification of inspection of all seals and sealing surfaces is performed per SIP 1128 by Vendor and USA SRBE. (Material or Manufacturing Defect)
- o Vendor inspection and test records are verified per SIP 1128 by USA SRBE PQAR. (All Failure Causes)
- o Verification of material certification is performed per SIP 1128 by USA SRBE. (Fractured Gear of Gear Tooth, Shaft Failure, Bearing Failure)
- o Verification of vendor buy off of all torque operations is performed per SIP 1128 Rev. by USA SRBE. (Material or Manufacturing Defect)

- o Witnessing of final acceptance test is performed per SIP 1128 by vendor and USA SRBE. (All Failure Causes)
- o Verifications that are required on new units are performed on refurbished units per SIP 1128 USA SRBE PQAR. (All Failure Causes)
- o Critical Processes/Inspections:
 - Welding per CP 05.15-01
 - Heat Treat per CP 09.9315-CHF-12-01
 - MPI per CP 16.04-01

KSC RELATED INSPECTIONS

- o Verification of lube oil (influent) for cleanliness and composition per 10REQ-0021, para. 2.3.2.3. (Contamination)
- o Verification of lube oil level per 10REQ-0021, para. 2.3.9.2 as called out in 10REQ-0021, paras. 2.3.11.1, 2.3.15.1 and 2.3.16.1 respectively for: (Fractured Gear or Gear Tooth, Shaft Failure, Bearing Failure)
 - Low speed GN2 spin preparation
 - High speed GN2 spin preparation
 - Hotfire preparation
- o Proper function of TVC system is demonstrated during hotfire operations per 10REQ-0021, paras. 2.3.11, 2.3.15 and 2.3.16 respectively for: (Fractured Gear or Gear Tooth, Shaft Failure, Bearing Failure)
 - Low speed GN2 spin
 - High speed GN2 spin
 - Hotfire
- o Verification of post hotfire gearbox lube oil cleanliness and composition (purity and particulate count) is performed per 10REQ-0021, para. 2.3.16.5. (Contamination)
- o Verification of proper lube oil level is performed per OMRSD File V, Vol. 1, Requirement Number B42AP0.040 prior to launch. (Fractured Gear or Gear Tooth, Shaft Failure, Bearing Failure)
- o The gearbox is monitored from APU start to lift off 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.

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