

System: SRMS

Subsystem: MECHANICAL ARM SUB-SYSTEM

Assembly Desc: END EFFECTOR

Part Number(s): 51140E1470-1 51140E1470-3

Name	Part Number(s)	Qty	Sheet No.	Schematic No.
Item: CAPTURE/ SNARE MECHANISM	51140E1477-1 51140E1477-3	1		

Function: CAPTURE/ SNARE MECHANISM DRIVES SNARE RING TO CAPTURE OR RELEASE A PAYLOAD.

Failure Mode: CAPTURE/SNARE DRIVE TRAIN FAILS FREE.

H/W Func. Screen Failures

Criticality: 1 1

Mission Phase: Orbit

Cause(s): CAPTURE/ SNARE MECHANISM

- (1) FAILURE OF BACKUP CLUTCH IN DISENGAGED POSITION.
- (2) GEAR OR SHAFT FAILURE.
- (3) GEAR FASTENER FAILURE.

Failure effect on unit/end item: LOSS OF ABILITY TO CAPTURE A PAYLOAD. IF A PAYLOAD IS CAPTURED IT WILL BE RELEASED. ARM WILL REMAIN LIMP IN AUTO CAPTURE SEQUENCE.

Worst Case: UNCOMMANDED RELEASE. CREW ACTION REQUIRED.

Redundant Paths: N/A

Retention Rationale

Design:

THE END EFFECTOR BACKUP RELEASE CLUTCH IS A MAJOR BOUGHT-OUT-PART WHICH IS SUPPLIED BY SPERRY CORPORATION, AEROSPACE AND MARINE GROUP AND MEETS OR EXCEEDS THE REQUIREMENTS OF SPECIFICATION SPAR-SG.53. IT SHOULD BE NOTED THAT THIS IS A DOG-TOOTH CLUTCH

THE CLUTCH SHAFT AND ARMATURE ARE CONNECTED BY A SPLINE WHICH PROVIDES ROTATION TO THE ARMATURE AND ALLOWS AXIAL SLIDING FOR ENGAGEMENT AND DISENGAGEMENT. THE FOLLOWING IS A LIST OF CHARACTERISTICS TO LIMIT THE POSSIBILITY OF THE CLUTCH HANGING-UP DUE TO MECHANICAL BINDING OF THE SPLINE:

THE SPLINES ARE MATCH-MACHINED FOR A PRECISE AND SMOOTH FIT.

SERIALIZATION OF THE MATCHED PARTS ASSURES PROPER ASSEMBLY.

THE MATCHED SHAFT AND ARMATURE ASSEMBLY IS INSPECTED FOR PROPER CLEARANCE AND SMOOTHNESS OF OPERATION.

THE UNIT IS TESTED A MINIMUM OF SEVEN TIMES DURING ACCEPTANCE TESTING FOR POTENTIAL BINDING. THE TEST CONSISTS OF APPLYING FULL RATED LOAD TORQUE WITH THE UNIT ENGAGED. A VOLTAGE IS THEN APPLIED TO DISENGAGE THE UNIT. THE TIME FROM APPLICATION OF VOLTAGE UNTIL FULL DISENGAGEMENT IS MEASURED. ANY BINDING OF THE ARMATURE WOULD EITHER PREVENT DISENGAGEMENT OR CAUSE AN EXCESSIVE TIME DELAY.

THE SPLINES ARE LUBRICATED WITH MOLYBDENUM DISULFIDE.

THE UNIT LOAD LEVELS ON THE SPLINE ARE LOW

IT SHOULD BE NOTED THAT THESE UNITS DO NOT UTILIZE REDUNDANT SPLINES.

THE BEARINGS ARE WELL LUBRICATED WITH BRAYCOTE 3L-38RP

MATERIALS SELECTION AND USAGE CONFORMS TO SPAR-SG.368 WHICH IS EQUIVALENT TO THE NASA MATERIALS USAGE REQUIREMENTS.

ALL SRMS GEARS ARE DESIGNATED IN ACCORDANCE WITH AGMA STANDARDS TO GIVE A MINIMUM OF INFINITE LIFE. THE DEFINITION OF INFINITE LIFE IS THE CONDITION WHERE 10⁷ MESH CYCLES OR MORE AT THE APPLIED LOAD WILL NOT RESULT IN TOOTH FAILURE.

UNIT LOADS WERE CALCULATED TO DETERMINE THE STRENGTH OF THE GEARS IN SNARE AND RIGIDIZE GEAR TRAINS. THE UNIT LOAD IN THIS CONTEXT, IS A STRESS INDICATOR AND IS GIVEN BY THE FOLLOWING FORMULA.

$$\text{UNIT LOAD} = \frac{(\text{TANGENTIAL GEAR LOAD})}{(\text{DIAMETRAL PITCH})} \times \frac{(\text{LOAD})}{(\text{FACE WIDTH})}$$

A VALUE OF 15,000 POUNDS PER IN., PER INCH (FOR STATIC CONDITIONS) WAS A DESIGN GOAL FOR GEARS IN THE END EFFECTOR. IT IS NOT A STRESS AND MUST NOT BE CONSIDERED AS A LIMITING OR ULTIMATE VALUE

THE STRUCTURAL ANALYSIS CONDUCTED ON THE END EFFECTOR, PER SPAR-TM.1531, CONFIRMED A POSITIVE MARGIN OF SAFETY FOR ALL END EFFECTOR PARTS AND GEARS. THE MARGIN OF SAFETY FOR ULTIMATE STRENGTH M(UTS) INCORPORATES A FACTOR OF SAFETY OF 1.4 AGAINST LIMIT LOAD, AS SPECIFIED IN SPAR-SG. 392. A NEGATIVE MARGIN DOES NOT NECESSARILY IMPLY BREAKAGE OF THE PART, RATHER IT INDICATES THAT A LIMITING STRESS LEVEL, ESTABLISHED BY THE FACTOR OF SAFETY, HAS BEEN EXCEEDED. THE MARGIN OF SAFETY FOR YIELD STRENGTH S(YIELD) EMPLOYS A FACTOR OF SAFETY OF 1.0 AGAINST LIMIT LOAD, AS SPECIFIED IN SPAR-SG.392. TABLE 14 LISTS MARGINS OF SAFETY FOR SRMS STRUCTURAL COMPONENTS. A FATIGUE ANALYSIS WHICH SHOWS INFINITE LIFE HAS BEEN PERFORMED ON THE GEARS AND MECHANICAL FASTENER AND A FRACTURE ANALYSIS WHICH SHOWS LIVES GREATER THAN 424 MISSIONS HAS BEEN DEMONSTRATED ON STRUCTURAL COMPONENTS WITHIN THE END EFFECTOR. A MARGIN OF SAFETY IN EXCESS OF 2.0 HAS BEEN DETERMINED FOR THE FASTENER CONNECTION BETWEEN THE QUADRANT GEAR AND THE ROTATING RING. FOR THIS CONNECTION TO FAIL A LOAD 2.4 TIMES GREATER THAN THE NORMAL OPERATING LOAD MUST BE APPLIED. THIS SITUATION IS HIGHLY UNLIKELY.

Test:

ACCEPTANCE TESTS - THE EE ASSEMBLY IS TESTED TO THE FOLLOWING ACCEPTANCE ENVIRONMENTS: VIBRATION: LEVEL AND DURATION - REFERENCE TABLE 7 THERMAL VACUUM: +70 DEGREES C TO -25 DEGREES C (1 1/2 CYCLES) 1 X 10⁻⁸ TORR

THE EE ASSEMBLY IS FURTHER TESTED IN THE IN THE RMS SYSTEM TEST (TP518 RMS STRONGBACK AND TP552 FLA1 FLOOR TESTS) WHICH VERIFIES THE ABSENCE OF THE FAILURE MODE.

QUALIFICATION TESTS - THE EE ASSEMBLY QUALIFICATION TESTING CONSISTED OF THE FOLLOWING ENVIRONMENTS: VIBRATION: LEVEL AND DURATION - REFERENCE TABLE 7 SHOCK: 20G/11 MS - 3 AXES (6 DIRECTIONS) THERMAL VACUUM: -81 DEGREES C TO -36 DEGREES C (6 CYCLES) 1 X 10⁻⁸ TORR HUMIDITY: 85% RH (65 DEGREES C MAINTAINED FOR 6 HRS) (85 DEGREES C TO 30 DEGREES C IN 16 HRS) 10 CYCLES 240 HRS. EMC: MIL-STD-461A AS MODIFIED BY SL-E-00X (TEST DE01, CE03, CS01, CS02, CS08, RE02 (N/B)). STRUCTURAL STIFFNESS AND LOAD TEST FLIGHT CHECKOUT PDRS OPS CHECKLIST (ALL VEHICLES) JSC 16987

Inspection:

UNITS ARE MAJOR BOUGHT OUT PARTS, MANUFACTURED, ASSEMBLED AND TESTED TO SPAR DRAWINGS AND SPECIFICATIONS UNDER DOCUMENTED QUALITY CONTROLS. THESE CONTROLS ARE EXERCISED THROUGHOUT DESIGN PROCUREMENT, PLANNING, PROCESSING, FABRICATION, ASSEMBLY QUALIFICATION AND ACCEPTANCE TESTING. MANDATORY INSPECTION POINTS ARE EMPLOYED AS APPROPRIATE AT VARIOUS LEVELS OF ASSEMBLY AND TEST. SPAR/GOVERNMENT SOURCE INSPECTION IS INVOKED ON THE SUPPLIER.

WIRE IS PROCURED TO SPECIFICATION MIL-W-22759 OR MIL-W-81381 AND INSPECTED AND TESTED TO NASA JSCM8080 STANDARD NUMBER 85A.

RECEIVING INSPECTION VERIFIES THAT THE HARDWARE RECEIVED IS AS IDENTIFIED IN THE PROCUREMENT DOCUMENTS, THAT NO DAMAGE HAS OCCURRED DURING SHIPMENT, AND THAT APPROPRIATE DATA HAS BEEN RECEIVED WHICH PROVIDES ADEQUATE TRACEABILITY INFORMATION AND IDENTIFIES ACCEPTABLE PARTS.

UNITS ARE INSPECTED TO THE APPLICABLE SPAR INSPECTION TEST PROCEDURE (ITP). PRIOR TO MM INTEGRATION INSPECTIONS INCLUDE CLEANLINESS USING U.V. GENERAL WORKMANSHIP, DIMENSIONAL, SPLINE FOR DRY LUBRICATION CORRECT INSTALLATION OF BEARING, WIRE LEADS FOR DAMAGE, IDENTIFICATION AND FUNCTIONAL TEST TO VERIFY BRAKE SLIP TORQUE, STICTION, DROPOUT VOLTAGE, PULL-IN VOLTAGE ETC.

PARTS ARE INSPECTED THROUGHOUT MANUFACTURE AND ASSEMBLY AS APPROPRIATE TO THE MANUFACTURING STAGE COMPLETED. THESE INSPECTIONS INCLUDE:

BEARINGS RECEIVE DIMENSIONAL INSPECTION AT THE SUPPLIER AND VERIFICATION BY SPAR RECEIVING INSPECTION. PRE ASSEMBLY INSPECTION VERIFIES CIRCULARITY OF BALL TRACKS AND INNER/OUTER RACE DIAMETERS. AFTER ASSEMBLY PRIOR TO LUBRICATION, RADIAL CLEARANCE MEASUREMENTS ARE TAKEN. FOLLOWING LUBRICATION, RUN-IN/BURNISHING AND CLEANING OF DRY LUBRICATION BEARINGS, SPECIALIZED BEARING INSPECTION EQUIPMENT AT SPAR IS USED TO VERIFY QUALITY AND STICTION LEVELS THROUGH STRIP CHART RECORDING OF TORQUE TRACES. BEARINGS ARE THEN RETURNED TO THE SUPPLIER FOR FINAL RADIAL CLEARANCE MEASUREMENTS. GOVERNMENT SOURCE INSPECTION IS INVOKED ON ALL BEARING PROCUREMENTS.

GEAR INSPECTION, BEFORE GEAR LUBRICATION AND RUN-IN A COMPOSITE ERROR GEAR CHECKER IS USED TO VERIFY THAT INVOLUTE FORM, PITCH CIRCLE CONCENTRICITY AND PITCH DIAMETER ARE TO DRAWING REQUIREMENTS. THIS INSPECTION ALSO INCLUDES TEXTURE EVALUATION. AFTER LUBRICATION, GEARS ARE VISUALLY INSPECTED TO CONFIRM APPROPRIATE LUBRICANT APPLICATION AND GEARS ARE THEN RUN-IN, CLEANED AND VISUALLY INSPECTED.

SHAFTS ARE DIMENSIONAL INSPECTED TO DRAWING REQUIREMENTS THROUGHOUT THE MANUFACTURING STAGES FOLLOWING HEAT TREATMENT THE SHAFTS ARE SUBJECTED TO MAGNETIC PARTICLE INSPECTION FOR CRACKS. INTEGRATION OF UNIT TO MOTOR MODULE INSPECTIONS INCLUDE GROUNDING CHECKS, CONNECTOR FOR BFN1 PINS, VISUAL, CLEANLINESS, INTERCONNECT WIRING ETC.

MOTOR MODULES ARE TESTED TO THE REQUIREMENTS OF SPAR-TM.1624 WHICH INCLUDES, CONTINUITY AND ISOLATION CHECKS, STICTION, COMMUTATOR TIMING, AMBIENT AND THERMAL TESTING (SPAR/GOVERNMENT RFP - MANDATORY INSPECTION POINT).

INTEGRATION OF MOTOR MODULE TO END EFFECTOR LRU - INSPECTIONS INCLUDE GROUNDING CHECKS, CONNECTORS FOR BENT OR PUSHBACK CONTACTS, INTERCONNECT WIRING ETC.

PRE ACCEPTANCE TEST INSPECTION, WHICH INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC. (MANDATORY INSPECTION POINT).

A TEST READINESS REVIEW (TRR) WHICH INCLUDES VERIFICATION OF TEST PERSONNEL, TEST DOCUMENTS, TEST EQUIPMENT CALIBRATION/VALIDATION STATUS AND HARDWARE CONFIGURATION IS CONVENED BY QUALITY ASSURANCE

IN CONJUNCTION WITH ENGINEERING, RELIABILITY, CONFIGURATION CONTROL, SUPPLIER AS APPLICABLE, AND THE GOVERNMENT REPRESENTATIVE, PRIOR TO THE START OF ANY FORMAL TESTING (ACCEPTANCE OR QUALIFICATION). ACCEPTANCE TESTING (ATP) INCLUDES, AMBIENT, VIBRATION AND THERMAL-VAC TESTING (SPAR/GOVERNMENT REP - MANDATORY INSPECTION POINT).
SRMS SYSTEMS INTEGRATION, THE INTEGRATION OF MECHANICAL ARM SUBASSEMBLIES AND THE FLIGHT CABIN EQUIPMENT TO FORM THE SRMS. INSPECTIONS ARE PERFORMED AT EACH PHASE OF INTEGRATION WHICH INCLUDES GROUNDING CHECKS, THRU WIRING CHECKS, WIRING ROUTING, INTERFACE CONNECTORS FOR BENT OR PUSH BACK CONTACTS ETC.
SRMS SYSTEMS TESTING - STRONGBACK AND FLAT FLOOR AMBIENT PERFORMANCE TEST (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT).

OMRSD Offline: PERFORM MANUAL CAPTURE/RELEASE FUNCTION. VERIFY CORRECT FLAG TIMING OPEN TO CLOSE

OMRSD Online Installation: NONE

OMRSD Online Turnaround: PERFORM MANUAL CAPTURE/RELEASE FUNCTION. VERIFY CORRECT FLAG TIMING OPEN TO CLOSE.

Screen Failure: A:
B:
C:

Crew Training: FOR UNDOCKED OPERATIONS: THE CREW WILL BE TRAINED TO MANEUVER THE ORBITER AWAY FROM A FREE FLYING PAYLOAD AT ANY TIME DURING ARM OPERATIONS.

Crew Action: FOR UNDOCKED OPERATIONS: MANEUVER ARM AND ORBITER AWAY FROM PAYLOAD.

Operational Effect: PAYLOAD WILL BE RELEASED WITH NO OPERATOR COMMAND. IF THIS OCCURS WHILE THE ARM IS BEING DRIVEN, THE PAYLOAD WILL TAKE AN UNEXPECTED TRAJECTORY DURING CAPTURE SEQUENCE ARM REMAINS LIMP UNTIL EE MODL SWITCH SET TO OFF

Mission Constraints: OPERATE UNDER VERNIER RATES WITHIN 10 FT OF STRUCTURE. THE OPERATOR MUST BE ABLE TO DETECT THAT THE ARM/PAYLOAD IS RESPONDING PROPERLY TO COMMANDS VIA WINDOW AND/OR CCTV VIEWS DURING ALL ARM OPERATIONS. EE MODE SWITCH SET TO OFF POSITION IMMEDIATELY AFTER SPEC DRIVE TIME HAS ELAPSED. WHEN CAPTURING A FREE FLYING PAYLOAD, THE EE MUST BE FAR ENOUGH AWAY FROM STRUCTURE TO PROHIBIT CONTACT REGARDLESS OF PAYLOAD ROTATIONS.

Approvals:

Functional Group	Name	Position	Telephone	Date Signed	Status
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