

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/R: 5114DE1472 TB 3 SHEET:

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE SCREENS: N/A
3810	3	RIGIDIZE MECHANISM QTY-1 PART OF 5114DE1472 -1A-3	<p>MODE: EE PERMANENTLY JAMMED.</p> <p>CAUSE(S): (1) AXIAL SEIZURE OF SPLINE WITH RIGIDIZATION OR DERIGIDIZATION</p>	<p>EE WILL NOT OPERATE IN ANY MODE. STRUCTURAL DAMAGE TO SHARE DRIVE PREVENTS ROTATION. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ.</p> <p>WORST CASE ----- UNEXPECTED PAYLOAD MOTION. INCOMPLETE CAPTURE/RELEASE SEQUENCE. UNABLE TO RELEASE PAYLOAD. CREW ACTION REQUIRED.</p> <p>REDUNDANT PATNS REMAINING ----- N/A</p>	<p>DESIGN FEATURES -----</p> <p>MATERIALS SELECTION AND USAGE CONFORMS TO SPAR-SG.368 WHICH IS EQUIVALENT TO THE NASA MATERIALS USAGE REQUIREMENTS.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>A FATIGUE ANALYSIS WHICH SHOWS INDEFINITE LIFE HAS BEEN PERFORMED ON THE GEARS AND MECHANICAL FASTENERS AND A FRACTURE ANALYSIS WHICH SHOWS LIVES GREATER THAN 424 MISSIONS HAS BEEN DEMONSTRATED ON STRUCTURAL COMPONENTS WITHIN THE END EFFECTOR.</p> <p>INVOLUTE SPLINE ASSEMBLY QUALIFICATION TESTING INCLUDED THERMAL/VACUUM LIFE CYCLE TESTING PERFORMED IN ACCORDANCE WITH SPAR-RMS-OTP.1036 AND DEMONSTRATED COMPONENT MISSION LIFE IN EXCESS OF 648 MISSIONS (2 TIMES A MISSION LIFE OF 424 MISSIONS) WITHOUT DEGRADATION IN PERFORMANCE. UNIT QUALIFICATION VIBRATION TESTING (QVT AND QAVT) WAS PERFORMED AT LEVELS 1.69 TIMES GREATER THAN END EFFECTOR LRU VIBRATION LEVELS TO VERIFY THE STRUCTURAL INTEGRITY OF THE INVOLUTE SPLINE ASSEMBLY. A POST QUALIFICATION TEST EVALUATION CONCLUDED THAT THE UNIT WAS STILL SERVICEABLE AND WAS NOT CONSIDERED TO BE A LIFE LIMITED ITEM. ALL END EFFECTOR MODELS ARE PRESENTLY EQUIPPED WITH INVOLUTE SPLINE ASSEMBLIES.</p> <p>DURING QUALIFICATION TESTING, A BALL SPLINE SEIZURE RESULTED IN THE FRACTURING OF THE SHARE DRIVE GEARBOX. SINCE THIS INCIDENT A SHARE DRIVE GEARBOX BRACE ARM HAS BEEN ADDED TO SUPPORT THIS MEMBER AND WAS QUALIFIED WITH THE END EFFECTOR.</p> <p>THE LIFE OF THE BEARING LUBRICATION HAS BEEN ANALYZED USING ULTIMATE LOADS TO EVALUATE HERTZIAN STRESSES. ULTIMATE LOAD = 1.4 X WORKING LOAD. THE LUBRICANT ON ALL BEARINGS IS GOOD FOR OVER 400 MISSIONS USING THE ULTIMATE LOADS.</p> <p>THE SOLID FILM LUBRICANT SYSTEM USED IS LUBECO 905. THIS COMPRISES A SPRAY AND CURE (400 DEGREES F) APPLICATION OF MOLYBDENUM DISULFIDE, IN AN INORGANIC BINDER DONE PER PPS.28:11 AND 28:13. BURNISHING AND RUN IN IS DONE IN ACCORDANCE WITH PPS.28:14.</p>	

PREPARED BY:

MFVG

SUPERSEDING DATE: 06 OCT 87

APPROVED BY:

DATE: 24 JUL 91

CIL REV: 3



CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-1A-3 SHEET: 2

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	NDNR / FUNC. 1/1	RATIONALE FOR ACCEPTANCE CRITICALITY SCREENS: N/A
3810	3	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1A-3	<p>MODE: EE PERMANENTLY JAMMED.</p> <p>CAUSE(S): (1) AXIAL SEIZURE OF SPLINE WITH RIGIDIZATION OR DERIGIDIZATION</p>	<p>EE WILL NOT OPERATE IN ANY MODE. STRUCTURAL DAMAGE TO SHARE DRIVE PREVENTS ROTATION. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ.</p> <p>WORST CASE ----- UNEXPECTED PAYLOAD MOTION. INCOMPLETE CAPTURE/RELEASE SEQUENCE. UNABLE TO RELEASE PAYLOAD. CREW ACTION REQUIRED.</p> <p>REDUNDANT PATHS REMAINING ----- N/A</p>		<p>ACCEPTANCE TESTS ----- THE EE ASSEMBLY IS TESTED TO THE FOLLOWING ACCEPTANCE ENVIRONMENTS:</p> <ul style="list-style-type: none"> O VIBRATION: LEVEL AND DURATION - REFERENCE TABLE 7 O THERMAL VACUUM: +70 DEGREES C TO -25 DEGREES C (1 1/2 CYCLES) 1 X 10**6 TORR <p>THE EE ASSEMBLY IS FURTHER TESTED IN THE IN THE RMS SYSTEM TEST (TP518 RMS STRONGBACK AND TP552 FLAT FLOOR TESTS) WHICH VERIFIES THE ABSENCE OF THE FAILURE MODE.</p> <p>QUALIFICATION TESTS ----- THE EE ASSEMBLY QUALIFICATION TESTING CONSISTED OF THE FOLLOWING ENVIRONMENTS:</p> <ul style="list-style-type: none"> O VIBRATION: LEVEL AND DURATION - REFERENCE TABLE 7 O SHOCK: 20G/11 MS - 3 AXES (6 DIRECTIONS) O THERMAL VACUUM: +81 DEGREES C TO -36 DEGREES C (6 CYCLES) 1 X 10**6 TORR O HUMIDITY: 95% RH (65 DEGREES C MAINTAINED FOR 6 HRS) (65 DEGREES C TO 30 DEGREES C IN 16 HRS) 10 CYCLES 240 HRS. O EMC: MIL-STD-461A AS MODIFIED BY SL-E-0002 (TEST CE01, CE03, CS01, CS02, CS06, RE02 (N/B)) O STRUCTURAL STIFFNESS AND LOAD TEST <p>FLIGHT CHECKOUT ----- PDRS OPS CHECKLIST (ALL VEHICLES) JSC 16987</p>

CRITICAL FAILURE LIST

PROJECT: ASS'Y MANUFACTURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140E1470-18-3

SHEET: 3

FMEA REF.	FMEA REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	MDWR / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE SCREENS: N/A
3010	3	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472-18-3	MODE: EE PERMANENTLY JAMMED. CAUSE(S): (1) AXIAL SEIZURE OF SPLINE WITH RIGIDIZATION OR DERIGIDIZATION	EE WILL NOT OPERATE IN ANY MODE. STRUCTURAL DAMAGE TO SHAFT DRIVE PREVENTS ROTATION. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE ----- UNEXPECTED PAYLOAD MOTION. INCOMPLETE CAPTURE/RELEASE SEQUENCE. UNABLE TO RELEASE PAYLOAD. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING ----- N/A	QA/INSPECTIONS	<p>UNITS ARE MANUFACTURED UNDER DOCUMENTED QUALITY CONTROLS. THESE CONTROLS ARE EXERCISED THROUGHOUT DESIGN PROCUREMENT, PLANNING, RECEIVING, PROCESSING, FABRICATION, ASSEMBLY, TESTING AND SHIPPING OF THE UNITS. MANDATORY INSPECTION POINTS ARE EMPLOYED AT VARIOUS STAGES OF FABRICATION ASSEMBLY AND TEST. GOVERNMENT SOURCE INSPECTION IS INVOKED AT VARIOUS CONTROL LEVELS.</p> <p>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.</p> <p>PARTS ARE INSPECTED THROUGHOUT MANUFACTURE AND ASSEMBLY AS APPROPRIATE TO THE MANUFACTURING STAGE COMPLETED. THESE INSPECTIONS INCLUDE,</p> <p>GEAR INSPECTION, BEFORE GEAR LUBRICATION AND RUN-IN A COMPOSITE ERROR GEAR CHECKER IS USED TO VERIFY THAT INVOLVE 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.</p> <p>FOLLOWING HEAT TREATMENT, STEEL PARTS (E.G. GEARS) ARE SUBJECTED TO A MAGNETIC PARTICLE INSPECTION FOR CRACKS OR IN THE CASE OF ALUMINUM PARTS (E.G. HOUSINGS) ARE DYE PENETRANT INSPECTED USING GROUP V PENETRANTS. WELDING OF GEARS OR HOUSINGS IS SUBJECTED TO DYE PENETRANT (GROUP V) AND RADIOGRAPHIC INSPECTION ON COMPLETION OF STRESS RELIEF TO CHECK FOR CRACKS. QUALIFICATION WELDING TEST SAMPLES FOR STRUCTURAL WELDS ARE SUBJECTED TO DESTRUCTIVE TESTING WHERE POSSIBLE (TENSILE AND BENDING) AS WELL AS METALLAGRAPHIC ANALYSIS TO ENSURE DEFECT FREE WELDS.</p> <p>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 LUBE 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.</p> <p>INSPECTION VERIFIES THAT KITTED PARTS ARE CORRECT PRIOR TO ASSEMBLY AND TRACEABILITY INFORMATION RECORDED.</p> <p>INSPECTION TO DRAWING IS CONDUCTED THROUGHOUT THE ASSEMBLY PROCESS, INCLUDING INSPECTION OF LOCKING, WITNESSING OF TORQUING AND APPLICATION OF TORQUE STRIPPING.</p>

PREPARED BY: MFNG SUPERCEDING DATE: 06 OCT 87 APPROVED BY: DATE: 24 JUL 91 CIL REV: 3

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140E1470-1A-3

SHEET: 4

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDMR / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE SCREENS: N/A
3810	3	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1A-3	<p>MODE: EE PERMANENTLY JAMMED.</p> <p>CAUSE(S): (1) AXIAL SEIZURE OF SPLINE WITH RIGIDIZATION OR DERIGIDIZATION</p>	<p>EE WILL NOT OPERATE IN ANY MODE. STRUCTURAL DAMAGE TO SHAFT DRIVE PREVENTS ROTATION. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ.</p> <p>WORST CASE ----- UNEXPECTED PAYLOAD MOTION. INCOMPLETE CAPTURE/RELEASE SEQUENCE. UNABLE TO RELEASE PAYLOAD. CREW ACTION REQUIRED.</p> <p>REDUNDANT PATHS REMAINING ----- N/A</p>	1/1	<p>PRE-ACCEPTANCE TEST INSPECTION, WHICH INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC., (MANDATORY INSPECTION POINT).</p> <p>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).</p> <p>ACCEPTANCE TESTING (ATP) INCLUDES, AMBIENT, VIBRATION AND THERMAL-VAC TESTING, (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)</p> <p>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 GENT OR PUSH BACK CONTACTS ETC.</p> <p>SRMS SYSTEMS TESTING - STRONGBACK AND FLAT FLOOR AMBIENT PERFORMANCE TEST. (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)</p>

PREPARED BY: MFVG

SUPERCEDING DATE: 06 OCT 87

APPROVED BY: _____

DATE: 24 JUL 91

CIL REV: 3

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/R: 51140E147D-1&3 SHEET: 5

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HWR / FUNC. 1/1	RATIONALE FOR ACCEPTANCE SCREENS: N/A
3810	3	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1&3	MODE: EE PERMANENTLY JAMMED. CAUSE(S): (1) AXIAL SEIZURE OF SPLINE WITH RIGIDIZATION OR DERIGIDIZATION	EE WILL NOT OPERATE IN ANY MODE. STRUCTURAL DAMAGE TO SNARE DRIVE PREVENTS ROTATION. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE UNEXPECTED PAYLOAD MOTION. INCOMPLETE CAPTURE/RELEASE SEQUENCE. UNABLE TO RELEASE PAYLOAD. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING N/A		FAILURE HISTORY ----- THERE HAVE BEEN NO FAILURES ASSOCIATED WITH THIS FAILURE MODE ON THE SRMS PROGRAM.

PREPARED BY: HFWG SUPERCEDING DATE: 06 OCT 87 APPROVED BY: _____ DATE: 24 JUL 91 CIL REV: 3

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: END EFFECTOR

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140E1470-1E-3

SHEET: 6

FMEA REF.	FMEA REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HMWR / FUNC. I/T CRITICALITY RATIONALE FOR ACCEPTANCE SCREENS: N/A
3810	3	RIGIDIZE MECHANISM QTY-1 PART OF 51140E1472 -1E-3	MODE: EE PERMANENTLY JAMMED. CAUSE(S): (1) AXIAL SEIZURE OF SPLINE WITH RIGIDIZATION OR DERIGIDIZATION	EE WILL NOT OPERATE IN ANY MODE. STRUCTURAL DAMAGE TO SNARE DRIVE PREVENTS ROTATION. ARM WILL STAY LIMP DURING AUTO CAPTURE SEQ. WORST CASE ----- UNEXPECTED PAYLOAD MOTION. INCOMPLETE CAPTURE/ RELEASE SEQUENCE. UNABLE TO RELEASE PAYLOAD. CREW ACTION REQUIRED. REDUNDANT PATHS REMAINING ----- N/A	OPERATIONAL EFFECTS ----- EE DOES NOT OPERATE NOMINALLY WHEN COMMANDED. ARM REMAINS LIMP UNTIL EE MODE SW. IS TURNED OFF DURING CAPTURE SEQ. CANNOT RELEASE PAYLOAD IN ANY MODE. EVA RELEASE OF GRAPPLE FIXTURE IS A DESIGN FEATURE, IF THIS IS NOT POSSIBLE PAYLOAD MUST BE JETTISONED WITH ARM. CREW ACTION ----- EVA RELEASE OF PAYLOAD. IF EVA NOT POSSIBLE THEN THE ARM/PAYLOAD COMBINATION MUST BE JETTISONED. CREW TRAINING ----- CREW WILL BE TRAINED TO RECOGNIZE OFF NOMINAL EE OPERATIONS. MISSION CONSTRAINT ----- WHEN CAPTURING A FREE FLYING PAYLOAD. THE EE MUST BE FAR ENOUGH AWAY FROM STRUCTURE TO PROHIBIT CONTACT REGARDLESS OF PAYLOAD ROTATIONS. EE MODE SWITCH SET TO OFF POSITION IMMEDIATELY AFTER SPEC DRIVE TIME HAS ELAPSED. OMRSD OFFLINE ----- PERFORM MANUAL RIGIDIZE. VERIFY CORRECT TIME TO RIGIDIZE. OMRSD ONLINE INSTALLATION ----- NONE OMRSD ONLINE TURNAROUND ----- PERFORM MANUAL RIGIDIZE. VERIFY CORRECT TIME TO RIGIDIZE.

PREPARED BY: MEWG

SUPERCEDING DATE: 06 OCT 87

RMS/MECH - 143

DATE: 24 JUL 91

CIL REV: 3