CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MECHANICAL ARM
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140J1565
SHEET: 1

FMEA REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/F CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N 51140J1219 ELBOW (1) P/N 51140E711 WRIST (1) P/N 51140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		DESIGN FEATURES --- THE SOLID FILM LUBRICANT SYSTEM USED IS LUBECO 905. THIS COMPRISES A SPRAY AND CURE (400 DEGREES F) APPLICATION OF MOLYDENUM DISULPHIDE, IN AN IN ORGANIC BINDER APPLIED PER PPS:28:11 AND 28:13. BURNISHING AND RUN IN PER SPAR PPS 28:14. THE LUBRICATED BEARING IS TORQUE TRACED TO ENSURE ACCEPTABILITY PER SPAR PPS.28:14. 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. AFTER THE INITIAL BUILD OF ALL JOINT GEARBOXES THEY ARE RUN IN (BOTH DIRECTIONS) BY ROTATING THE JOINT TEN COMPLETE REVOLUTIONS. THE GEARBOXES ARE THEN COMPLETELY DISASSEMBLED AND CLEANED TO REMOVE ANY DRY LUBRICATION DEBRIS GENERATED FROM GEAR MESHING ACTION. A HIGH PRECENTAGE OF LUBRICATION DEBRIS IS CAUSED AT INITIAL USE OF DRY LUBED COMPONENTS. VENT HOLES WHICH ALLOW THE GEARBOX TO BREATH DO PROIDE A PATH FOR EXTERNAL DEBRIS BUT THIS PATH IS TORTUOUS AND IT IS UNLIKELY THAT ANY SIGNIFICANT PARTICLES WILL PASS INTO THE GEAR MESH AREA. SILICONE COATED FIBRE GLASS SEALS ARE USED TO PREVENT DEBRIS INGRESS INTO THE JOINT MAIN BEARINGS.

PREPARED BY: MWG
SUPERCEDING DATE: 06 OCT 87
APPROVED BY: _____
DATE: _____

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SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140J1565
SHEET: 2

FMEA REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N 51140J1219 ELBOW (1) P/N 51140E711 WRIST (1) P/N 51140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		ACCEPTANCE TESTS --- THE SHOULDER, ELBOW AND WRIST JOINTS ARE SUBJECTED TO THE FOLLOWING ACCEPTANCE ENVIRONMENTAL TESTING. O VIBRATION: LEVEL AND DURATION - REFERENCE TABLES 9, 10 AND 11. O THERMAL: +70 DEGREES C TO -25 DEGREES C (2 CYCLES) 1 X 10**6 TORR. THE JOINTS ARE INTEGRATED INTO THE RMS SYSTEM (PER TP532) WHICH IS FURTHER TESTED IN (TP518 RMS STRONGBACK AND TP552 FLAT FLOOR). THESE TESTS VERIFIES THE ABSENCE OF THE FAILURE MODE. QUALIFICATION TESTS --- THE SHOULDER AND WRIST JOINTS WERE SUBJECTED TO THE LISTED BELOW ENVIRONMENTS. THE ELBOW JOINTS WAS NOT EXPOSED THE QUALIFICATION ENVIRONMENTS WAS CERTIFIED BY SIMILARITY TO THE SHOULDER JOINT. O VIBRATION: LEVEL AND DURATION REFERENCE TABLES 9 AND 10 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 EMC: MIL-STD-461 AS MODIFIED BY SL-E-0002 (TESTS CE01, CE03, CS01, CS02, CS06, RE02 (N/B). O HUMIDITY: ONLY SHOULDER JOINT WAS TESTED. 95% RH (65 DEGREES C MAINTAINED FOR 6 HRS.) (65 DEGREES C TO 30 DEGREES C IN 16 HRS) 10 CYCLES 240 HRS. O LOAD TEST: SHOULDER JOINT STRUCTURAL LOAD TEST REFERENCE TABLE 12. NOTE: ELBOW JOINT (S/N 302 AND UP) INCORPORATES NON-WELDED TRANSITIONS WHICH WAS LOAD TESTED TO LOAD IN REFERENCE TABLE TBS. FLIGHT CHECKOUT --- PDRS OPS CHECKLIST (ALL VEHICLES) JSC 16987

PREPARED BY: MFMG
SUPERCEDING DATE: 06 OCT 87
APPROVED BY:

CRITICAL ITEMS LIST

PROJECT: SAMS
ASS'Y NOMENCLATURE: MECHANICAL ARM
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140J1565
SHEET: 3

FMEA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N 51140J1219 ELBOW (1) P/N 51140E711 WRIST (1) P/N 51140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		QA/INSPECTIONS --- JOINTS ARE MANUFACTURED, ASSEMBLED AND TESTED UNDER DOCUMENTED QUALITY CONTROLS TO SPAR AND CUSTOMER REQUIREMENTS. THESE CONTROLS ARE EXERCISED THROUGHOUT DESIGN PROCUREMENT, PLANNING, PROCESSING, FABRICATION, ASSEMBLY AND TESTING OF JOINTS. SPAR/GOVERNMENT REPRESENTATIVE MANDATORY INSPECTION POINTS ARE ENVOKED AT ALL LEVELS OF ASSEMBLY AND TEST. 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. 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 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 ENVOKED 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. JOD LEVEL PRE-ACCEPTANCE TEST INSPECTION INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC. (SPAR/GOVERNMENT REP. - 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). JOD LEVEL AMBIENT ACCEPTANCE TESTING (ATP) CONSIST OF CURRENT SIGNATURE AND LIMIT STOP LOAD TEST, JOINT RATE, JOINT ANGULAR TRAVEL AND FORWARD DRIVE THRESHOLD OF MOVEMENT TESTS.

PREPARED BY: MFWG
SUPERCEDING DATE: 06 OCT 87
APPROVED BY: _____ DATE: _____

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MECHANICAL ARM
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51T40J1565
SHEET: 4

FMEA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOUR / FUNC. F/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	J	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N 51140J1219 ELBOW (1) P/N 51T140E711 WRIST (1) P/N 51140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		(SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT) JOINT LEVEL PRE-ACCEPTANCE TEST INSPECTION. INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC. JOINT LEVEL ACCEPTANCE TESTING (ATP) INCLUDES AMBINET, 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)

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APPROVED BY:

CRITICAL ITEMS LIST

PROJECT: SAMS
ASS'Y NOMENCLATURE: MECHANICAL ARM
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140J1565
SHEET: 5

FMEA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N 51140J1219 ELBOW (1) P/N 51140E711 WRIST (1) P/N 51140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		FAILURE HISTORY --- THE FOLLOWING FAILURE ANALYSIS REPORT(S) ARE RELEVANT: FAR 2336: S/N 301 SEP 82 DESCRIPTION --- YAW FAILED BACKDRIVE STICTION, DESIGN TOLERANCE, O.K. AT +650C. CORRECTIVE ACTION --- WAIVER W0513 FAR 2341: S/N 302 SEP 82 DESCRIPTION --- FAILED TO RESPOND REFER TO FAR-RMS 2363. CORRECTIVE ACTION --- REFER TO FAR-RMS-2363. FAR 2363: S/N 302 JUL 83 DESCRIPTION --- FAILED TO DRIVE, FOUND COLD SOLDER JOINT ON M/M CSA OUTPUT. CORRECTIVE ACTION --- REPLACED M/M REWORKED M/M FAR 2365: S/N 303 AUG 83 DESCRIPTION --- PITCH JOD SHOWED CYCLIC VARIATIONS AT 14.5 M/M REVS. FOUND ANTI-BACKLASH SPRINGS INTERFERRING. SPRINGS STIFFER THAN REQUIRED. CORRECTIVE ACTION --- MODIFIED SPRINGS TO SEAT EFFECTIVELY. FAR 2366: S/N 303-1 SEP 83

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ATE: ___

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PROJECT: SRMS
ASS'Y NOMENCLATURE: MECHANICAL ARM
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140J1565
SHEET: 6

FMEA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. I/I CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N 51140J1219 ELBOW (1) P/N 51140E711 WHIST (1) P/N 51140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		DESCRIPTION --- YAW JOD, CYCLIC VARIATIONS ON CURRENT TRACE. REFER TO FAR 2365. CORRECTIVE ACTION --- REFER TO FAR 2365. FAR 2369: S/N 303 NOV 81 DESCRIPTION --- YAW JOD, HIGH STICTION CAUSE UNKNOWN, SUSPECT DRY LUBE RUN-IN. CORRECTIVE ACTION --- NONE FAR 2377: S/N 304-5 JUN 84 DESCRIPTION --- RUNNING FRICTION TOO HIGH, INTERFERENCE BETWEEN TACH STATOR/ROTOR, POOR WORKMANSHIP. CORRECTIVE ACTION --- ECN 51140D2094-11 CLARIFIED VENDOR FAB. UNIT REWORKED. FAR 2387: S/N 202 OCT 85 DESCRIPTION --- PITCH STALL TORQUE TOO LOW. CAUSE UNKNOWN, SUSPECT LARGE OUTPUT BEARING. CORRECTIVE ACTION --- WAIVER W00527 FAR 2393: S/N 201 JUNE 86 DESCRIPTION --- CURRENT SPIKES. CORRECTIVE ACTION --- DISASSEMBLED AND CLEANED.

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CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MECHANICAL ARM
SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: S1140J1565
SHEET: 1

FMEA REF.	REV.	NAME, QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HDWR / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4000	L	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER (1) P/N S1140J1219 ELBOW (1) P/N S1140E711 WRIST (1) P/N S1140J754	MODE: LOWER THAN COMMANDED JOINT RATE OR REDUCED TORQUE OUTPUT. CAUSE(S): (1) WEAROUT OF LUBRICANT IN BEARING OR ON GEARS. (2) DEBRIS INGRESS.	MOVEMENT OF THE JOINT WILL BE DEGRADED. (SLUGGISH). ARM MAY TAKE AN UNEXPECTED TRAJECTORY. WORST CASE --- UNEXPECTED MOTION. SLUGGISH JOINT. UNANNUNCIATED. CREW ACTION REQ. REDUNDANT PATHS REMAINING --- N/A		OPERATIONAL EFFECTS --- ARM DOES NOT RESPOND PROPERLY TO COMMANDS. FOR HAND CONTROLLER COMMANDS CREW INHERENTLY COMPENSATES FOR ANY UNDESIRED ARM TRAJECTORY. CREW ACTION --- APPLY BRAKES. CREW TRAINING --- THE CREW WILL BE TRAINED TO OBSERVE WHETHER THE ARM IS RESPONDING PROPERLY TO COMMANDS. IF IT ISN'T, APPLY BRAKES. MISSION CONSTRAINT --- OPERATE UNDER VERNIER RATES WITHIN 10 FT OF STRUCTURE. THE OPERATOR MUST BE ABLE TO DETECT THAT THE ARM IS RESPONDING PROPERLY TO COMMANDS VIA WINDOW AND/OR CCTV VIEWS DURING ALL ARM OPERATIONS. AUTOTRAJECTORIES MUST BE DESIGNED TO COME NO CLOSER THAN 5 FT FROM STRUCTURE. SCREEN FAILURES --- N/A OMRSD OFFLINE --- IN DIRECT DRIVE WITH ELBOW DEMATED VERIFY RATES FOR ALL JOINTS OMRSD ONLINE INSTALLATION --- NONE OMRSD ONLINE TURNAROUND --- NONE

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