

CRITICAL ITEMS LIST

PROJECT: SRMS
ASS'Y NOMENCLATURE: MECHANICAL ARM

SYSTEM: MECHANICAL ARM SUBSYSTEM
ASS'Y P/N: 51140J565

SHEET: 1

ITEM REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	NO. / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4010	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER P/N 51140J1219 ELBOW P/N 51140E711 WRIST P/N 51140J754	MODE: JOINT MOVEMENT UNRESTRAINED CAUSE(S): (1) FRACTURED GEAR. (2) FRACTURED HOUSING. (3) FRACTURED SHAFT.	JOINT WILL NOT RESPOND TO COMMANDS (FREE). CANNOT BE RESTRAINED BY BRAKES. JOINT WILL BE UNABLE TO COUNTERACT EXTERNAL FORCES. JOINT FRICTION MAY EVENTUALLY BRING THE JOINT TO REST. ARM WILL TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES (TACH DATA) BUT FAILED JOINT WILL BE UNRESTRAINED. WORST CASE UNEXPECTED MOTION. FREE JOINT. REDUNDANT PATHS REMAINING N/A		DESIGN FEATURES 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 10 ⁶ MESH CYCLES OR MORE AT THE APPLIED LOAD WILL NOT RESULT IN TOOTH FAILURE. THE APPLIED LOADS DERIVED FOR THIS (THESE) GEAR (S) WERE CATERED TO IN THE SIZING OF THE GEAR MESH. THE MATERIAL ALLOWABLES WERE DERATED BY SPAR AS CONSISTENT FOR FINE PITCH GEARING APPLIED TO POWER TRANSMISSIONS. THE RESULTING MESH DESIGN WAS CHECKED AGAINST THE INFINITE LIFE CRITERIA. THE SHOULDER AND ELBOW JOINTS ARE STIFFNESS DESIGNED. THE WRIST JOINT IS STRENGTH DESIGNED. THE STRUCTURAL ANALYSIS PERFORMED ON ALL THREE JOINTS IS CONSERVATIVE WITH ALL MARGINS OF SAFETY BEING POSITIVE. REF. STRUCTURAL ANALYSIS OF SRMS SPAR-TM.1531 AND SPAR-R.646. ALL ITEMS OF THE JOINT STRUCTURE HAVE BEEN INSPECTED FOR CRACKS, WHERE THE LIFE ANALYSIS HAS CALLED FOR A SPECIAL INSPECTION THIS HAS BEEN PERFORMED AND WHERE NECESSARY ALL CRACK LIKE INDICATIONS HAVE BEEN REMOVED. THE FRACTURE ANALYSIS, WHICH ASSUMES AN INITIAL CRACK LENGTH OF .05 INCHES TO .15 INCHES, .75 OF THE JOINT COMPONENTS SHOW THAT ALL ITEMS ARE CAPABLE OF PERFORMING OVER 400 MISSIONS WITHOUT COMPLETE FAILURE. FRACTURE ANALYSES ARE CONTAINED IN SPAR-TM.1531 AND SPAR-R.646.

PREPARED BY: HFWG

SUPERSEDING DATE: 12 OCT 89

APPROVED BY

ATE: _____

CRITICAL ITEMS LIST

PROJECT: SRMS
 ASS'Y NOMENCLATURE: MECHANICAL ARM

SYSTEM: MECHANICAL ARM SUBSYSTEM
 ASS'Y P/N: 51140J1585

SHEET: 2

PMA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOUR / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4010	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER P/N 51140J1219 ELBOW P/N 51140E711 WRIST P/N 51140J754	MODE: JOINT MOVEMENT UNRESTRAINED CAUSE(S): (1) FRACTURED GEAR. (2) FRACTURED HOUSING. (3) FRACTURED SHAFT.	JOINT WILL NOT RESPOND TO COMMANDS (FREE). CANNOT BE RESTRAINED BY BRAKES. JOINT WILL BE UNABLE TO COUNTERACT EXTERNAL FORCES. JOINT FRICTION MAY EVENTUALLY BRING THE JOINT TO REST. ARM WILL TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES (TACH DATA) BUT FAILED JOINT WILL BE UNRESTRAINED. WORST CASE UNEXPECTED MOTION. FREE JOINT. 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 K 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 K 10 ⁻⁶ TORR. O EMC: MIL-STD-461 AS MODIFIED BY SL-E-0002 (TESTS CE01, CE03, CS01, CS02, CS06, RE02 (N/D)). 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 10S. FLIGHT CHECKOUT PDORS OPS CHECKLIST (ALL VEHICLES) JSC 16987

PREPARED BY: HWG

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SHEET: 3

FMEA REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOWR / FUNC. I/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4010	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER P/N 51140J1219 ELBOW P/N 51140E711 WRIST P/N 51140J754	MODE: JOINT MOVEMENT UNRESTRAINED CAUSE(S): (1) FRACTURED GEAR. (2) FRACTURED HOUSING. (3) FRACTURED SHAFT.	JOINT WILL NOT RESPOND TO COMMANDS (FREE). CANNOT BE RESTRAINED BY BRAKES. JOINT WILL BE UNABLE TO COUNTERACT INTERNAL FORCES. JOINT FRICTION MAY EVENTUALLY BRING THE JOINT TO REST. ARM WILL TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES (TACH DATA) BUT FAILED JOINT WILL BE UNRESTRAINED. WORST CASE UNEXPECTED MOTION. FREE JOINT. REDUNDANT PATHS REMAINING N/A	QA/INSPECTIONS	<p>JOINTS ARE MANUFACTURED, ASSEMBLED AND TESTED UNDER DOCUMENTED QUALITY CONTROLS TO SPAN AND CUSTOMER REQUIREMENTS. THESE CONTROLS ARE EXERCISED THROUGHOUT DESIGN PROCUREMENT, PLANNING, PROCESSING, FABRICATION, ASSEMBLY AND TESTING OF JOINTS.</p> <p>SPAR/GOVERNMENT REPRESENTATIVE MANDATORY INSPECTION POINTS ARE ENVOCKED AT ALL LEVELS OF ASSEMBLY AND TEST.</p> <p>RECEIVING INSPECTION VERIFIES THAT PARTS, I.E. JOINT HOUSINGS AND BEARINGS RECEIVED ARE AS IDENTIFIED IN THE PROCUREMENT DOCUMENTS, THAT NO PHYSICAL DAMAGE HAS OCCURRED IN SHIPMENT, AND THAT THE RECEIVING DOCUMENTS PROVIDE ADEQUATE TRACEABILITY INFORMATION.</p> <p>PARTS ARE INSPECTED THROUGHOUT MANUFACTURE AND ASSEMBLY AS APPROPRIATE TO THE MANUFACTURING STAGE COMPLETED. THESE INSPECTIONS INCLUDE,</p> <p>CARPENTER 455 STEEL USED FOR THE MANUFACTURE OF (E.G. GEARS) RECEIVES ADDITIONAL LABORATORY INSPECTIONS WHICH INCLUDE CHEMICAL ANALYSIS, INCLUSION RATING, HARDNESS AND TENSILE TESTING TO VERIFY THE PROPERTIES OF THE MATERIAL SUPPLIED.</p> <p>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.</p> <p>POST MACHINING INSPECTION OF THE HOUSING VERIFIES DIMENSIONAL MANUFACTURE TO DRAWING USING CONVENTIONAL MEASURING TECHNIQUES AND A COMPUTERIZED COORDINATE CHECKER.</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>SHAFTS ARE DIMENSIONAL INSPECTED TO DRAWING REQUIREMENTS THROUGHOUT THE MANUFACTURING STAGES. FOLLOWING HEAT TREATMENT THE SHAFTS ARE SUBJECTED TO MAGNETIC PARTICLE INSPECTION FOR CRACKS.</p> <p>INSPECTION VERIFIES THAT KITTED PARTS ARE CORRECT PRIOR TO ASSEMBLY AND TRACEABILITY INFORMATION RECORDED.</p>

PREPARED BY: MJVG

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SHEET: 4

ITEM REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HOUR / FUNC. I/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
4010	1	TYPICAL JOINT (MECHANICAL) QTY-3 SHOULDER P/N 51140J1219 ELBOW P/N 51140E711 WRIST P/N 51140J754	MODE: JOINT MOVEMENT UNRESTRAINED CAUSE(S): (1) FRACTURED GEAR. (2) FRACTURED HOUSING. (3) FRACTURED SHAFT.	JOINT WILL NOT RESPOND TO COMMANDS (FREE). CANNOT BE RESTRAINED BY BRAKES. JOINT WILL BE UNABLE TO COUNTERACT EXTERNAL FORCES. JOINT FRICTION MAY EVENTUALLY BRING THE JOINT TO REST. ARM WILL TAKE AN UNEXPECTED TRAJECTORY. CONSISTENCY CHECK WILL INITIATE AUTO BRAKES (TACH DATA) BUT FAILED JOINT WILL BE UNRESTRAINED. WORST CASE ----- UNEXPECTED MOTION. FREE JOINT. REDUNDANT PATHS REMAINING ----- N/A		<p>JOB 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)</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>JOB 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. (SPAR/GOVERNMENT REP. - MANDATORY INSPECTION POINT)</p> <p>JOINT LEVEL PRE-ACCEPTANCE TEST INSPECTION, INCLUDES AN AUDIT OF LOWER TIER INSPECTION COMPLETION, AS BUILT CONFIGURATION VERIFICATION TO AS DESIGN ETC.</p> <p>JOINT LEVEL 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 BENT 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: MFNG

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SHEET: 5

FMEA REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HORN / FUNC. 1/1 CRITICALITY RATIONALE FOR ACCEPTANCE
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P/N & REF.	REV.	NAME, QTY, & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	HORN / FUNC. 1/1 CRITICALITY RATIONALE FOR ACCEPTANCE
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SHEET: 7

FMEA REF.	REV.	NAME QTY & DRAWING REF. DESIGNATION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON END ITEM	RDM / FUNC. 1/1 CRITICALITY	RATIONALE FOR ACCEPTANCE
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PREPARED BY: MFG

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