SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group:	**Actuators**	**Prepared:**	**S. Heater**
CIL Item:	**E120-05**	**Approved:**	**T. Nguyen**
Part Number:	**RES1008-5XXX**	**Approval Date:**	**6/9/00**
Component:	**Main Oxidizer Valve Actuator**	**Change #:**	**1**
FMEA Item:	**E120**	**Directive #:**	**CCBD ME3-01-5624**
Failure Mode:	**Erroneous feedback signal.**	**Page:**	**1 of 1**

Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.3	Erroneous feedback signal within limits or if SEII fails results in loss of actuator position protection. Loss of vehicle due to oxidizer duct rupture may result if MOVA/MOV closes and is not detected. Redundancy Screens: ACTUATOR SYSTEM: LIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Fail - Loss of redundant hardware items could result from a single credible event.	1R ME-C3S, ME-B4S
M 4.1	Controller switches to channel B (servovalve No. 2) when detected by SEII, or by the RVDT comparison test when HPOTP or HPFTP turbine discharge temperatures are outside blueline limits; continuation of failure, controller initiates hydraulic lockup all actuators. Mission abort may result when hydraulic lockup occurs during Max Q throttling. Redundancy Screens: ACTUATOR SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-C3M
M 4.2	The control system compensates for the RVDT slow drift of both feedback signals indicates MOV position greater than full open. Controller compensates by closing MOVA/MOV. HPOTP turbine discharge temperature exceeded. Mission abort. Redundancy Screens: ACTUATOR SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-C3M
M 4.3	Erroneous feedback signal within limits results in loss of actuator position limit protection. Loss of vehicle due to oxidizer duct rupture may result if MOVA/MOV closes and is not detected. Redundancy Screens: SENSOR SYSTEM - ACTUATOR SYSTEM: UNLIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-C3M

SSME . .MEA/CIL DESIGN

Component Group:	Actuators
CIL Item:	E120-05
Part Number:	RES1008-5XXX
Component:	Main Oxidizer Valve Actuator
FMEA Item:	E120
Failure Mode:	Erroneous feedback signal.

Prepared:	S. Heater
Approved:	T. Nguyen
Approval Date:	6/9/00
Change #:	1
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Design / Document Reference

FAILURE CAUSE: A: RVDT: Open or short circuit.

BOTH MOXON AND HYDRAULIC RESEARCH RVDTs ARE USED INTERCHANGEABLY ON THE ACTUATORS. SEPARATE RATIONALE IS PROVIDED UNDER EACH CAUSE. THE HYDRAULIC RESEARCH RVDT INCORPORATES A SHAFT SEAL ON THE ROTOR. THE SEAL IS A DESIGN ENHANCEMENT WHICH PROVIDES ADDITIONAL SPOOL TUBE CONTAMINATION PROTECTION.

HYDRAULIC RESEARCH RVDTs:

THE ELECTRICAL HARNESS WIRE AND RVDT COIL WIRE ARE IN ACCORDANCE WITH GOVERNMENT SPECIFICATIONS (1). THE EXIT OF THE WIRES FROM THE RVDT IS VIA A GLASS-SEALED HEADER (2). HARNESS WIRES ARE INSTALLED IN TEFLON-LINED WIREWAYS WHICH ARE FILLED WITH PLASTIC POTTING COMPOUND TO PREVENT MECHANICAL DAMAGE TO THE INSULATION AND WIRE (3). COIL AND LEADWIRE TERMINATIONS ARE ENCAPSULATED WITHIN THE RVDT BODY. RESISTORS, BALCO RESISTORS, AND THERMISTORS MEET EEE PARTS REQUIREMENTS AND ARE POTTED IN PLACE ALONG WITH THEIR CONNECTING WIRES (1). THERMISTORS ARE ENCAPSULATED WITH MULTIPLE EPOXY COATS FOR IMPROVED THERMAL INTEGRITY (4). COIL WIRES ARE WET WOUND ONTO THE BOBBINS WITH EPOXY RESIN (3). ELECTRICAL CONTINUITY AT COIL TO LEADWIRE, RESISTORS, THERMISTORS, AND LEADWIRES-TO-TERMINALS, AND LEADWIRES-TO-CONNECTORS IS ENSURED BY SOLDER JOINTS (1). CLEANLINESS REQUIREMENTS OF THE RVDT ARE MAINTAINED PER DRAWING REQUIREMENTS (2).

MOXON RVDTs:

THE ELECTRICAL HARNESS WIRE AND RVDT COIL WIRE ARE IN ACCORDANCE WITH GOVERNMENT SPECIFICATIONS (1). THE EXIT OF THE WIRES FROM THE RVDT IS VIA A GLASS-SEALED HEADER (5). HARNESS WIRES ARE INSTALLED IN TEFLON-LINED WIREWAYS WHICH ARE FILLED WITH PLASTIC POTTING COMPOUND TO PREVENT MECHANICAL DAMAGE TO THE INSULATION AND WIRE (6). COIL AND LEADWIRE TERMINATIONS ARE ENCAPSULATED WITHIN THE RVDT BODY. RESISTORS, BALCO RESISTORS, AND THERMISTORS MEET EEE PARTS REQUIREMENTS AND ARE POTTED IN PLACE ALONG WITH THEIR CONNECTING WIRES (1). THERMISTORS ARE ENCAPSULATED WITH MULTIPLE EPOXY COATS FOR IMPROVED THERMAL INTEGRITY (7). COIL WIRES ARE WET WOUND ONTO THE BOBBINS WITH EPOXY RESIN (6). ELECTRICAL CONTINUITY AT COIL TO LEADWIRE, RESISTORS, THERMISTORS, AND LEADWIRES-TO-TERMINALS, AND LEADWIRES-TO-CONNECTORS IS ENSURED BY SOLDER JOINTS (1). CLEANLINESS REQUIREMENTS OF THE RVDT ARE MAINTAINED PER DRAWING REQUIREMENTS (5).

(1) RC1008; (2) 88000300; (3) 88000708; (4) 88000310; (5) 104500; (6) 104082; (7) 104417

Design / Document Reference

FAILURE CAUSE: B: RVDT: Bearing failure.

BOTH MOXON AND HYDRAULIC RESEARCH RVDTs ARE USED INTERCHANGEABLY ON THE ACTUATORS. SEPARATE RATIONALE IS PROVIDED UNDER EACH CAUSE. THE HYDRAULIC RESEARCH RVDT INCORPORATES A SHAFT SEAL ON THE ROTOR. THE SEAL IS A DESIGN ENHANCEMENT WHICH PROVIDES ADDITIONAL SPOOL TUBE CONTAMINATION PROTECTION.

HYDRAULIC RESEARCH RVDTs:

THE RVDT INCORPORATES THREE BEARINGS ON THE ROTOR ASSEMBLY (1). THE FORWARD BEARING (2) IS A LUBRICATED PRECISION DUPLEXED PAIR PRELOADED TO ELIMINATE RADIAL PLAY. THE REAR BEARING IS A LUBRICATED PRECISION SINGLE BEARING (3). THE MID-BEARING (4) IS AN ALUMINUM-BRONZE (EVERDUR 6421) JOURNAL BEARING WHICH IS ATTACHED TO THE ROTOR WITH EPOXY (7). THE FORWARD AND REAR BEARING RACES, AND BALLS ARE HEAT TREATED 440C CRES (2)(3). THE MATERIAL WAS SELECTED FOR ITS HERTZ STRESS CAPABILITY, WEAR RESISTANCE, AND CORROSION RESISTANCE (5). EVERDUR 6421 WAS SELECTED FOR THE MID-BEARING FOR ITS WEAR RESISTANCE AND NON-MAGNETIC CHARACTERISTIC (5). BEARING LOADS ARE MINIMIZED BY DRIVING THE RVDT WITH A PIN OPERATING IN THE DRIVE BAR SLOT (6).

MOXON RVDTs:

THE RVDT INCORPORATES THREE BEARINGS ON THE ROTOR ASSEMBLY (8). THE FORWARD BEARING (9) IS A LUBRICATED PRECISION DUPLEXED PAIR PRELOADED TO ELIMINATE RADIAL PLAY. THE REAR BEARING IS A LUBRICATED PRECISION SINGLE BEARING (10). THE MID-BEARING (11) IS AN ALUMINUM-BRONZE (EVERDUR 6421) JOURNAL BEARING WHICH IS ATTACHED TO THE ROTOR WITH EPOXY (8). THE FORWARD AND REAR BEARING RACES, AND BALLS ARE HEAT TREATED 440C CRES (9) (10). THE MATERIAL WAS SELECTED FOR ITS HERTZ STRESS CAPABILITY, WEAR RESISTANCE, AND CORROSION RESISTANCE (5). EVERDUR 6421 WAS SELECTED FOR THE MID-BEARING FOR ITS WEAR RESISTANCE AND NON-MAGNETIC CHARACTERISTIC (5). BEARING LOADS ARE MINIMIZED BY DRIVING THE RVDT WITH A PIN OPERATING IN THE DRIVE BAR SLOT (6).

(1) 8800340; (2) 88000342; (3) 88000343; (4) 88000346; (5) RSS-8575; (6) 41003730; (7) 88000344; (8) 104059; (9) 104059-3; (10) 104059-2; (11) 104060

FAILURE CAUSE: C: RVDT: Spool tube contamination.

BOTH MOXON AND HYDRAULIC RESEARCH RVDTs ARE USED INTERCHANGEABLY ON THE ACTUATORS. SEPARATE RATIONALE IS PROVIDED UNDER EACH CAUSE. THE HYDRAULIC RESEARCH RVDT INCORPORATES A SHAFT SEAL ON THE ROTOR. THE SEAL IS A DESIGN ENHANCEMENT WHICH PROVIDES ADDITIONAL SPOOL TUBE CONTAMINATION PROTECTION.

HYDRAULIC RESEARCH RVDTs:

THE RVDT IS ASSEMBLED IN A CONTAMINATION CONTROLLED ENVIRONMENT. THE RVDT PARTS ARE CLEANED PRIOR TO ASSEMBLY (1). THE BEARING (2)(3)(4) MATERIALS ARE SELECTED FOR WEAR RESISTANCE (5) TO PREVENT CONTAMINATION GENERATION WITHIN THE SPOOL TUBE. THERE IS NO PHYSICAL CONTACT BETWEEN THE ROTOR AND THE SPOOL TUBE TO GENERATE CONTAMINATION. THE SPOOL TUBE IS PROTECTED FROM CONTAMINATION WITH HYDRAULIC OIL BY THE ACTUATOR SHAFT SEAL, A VENT-TO-DRAIN (6), AND AN RVDT SHAFT SEAL (7). THE SPOOL TUBE IS PROTECTED FROM EXTERNAL CONTAMINATION BY A SEAL BETWEEN THE ACTUATOR AND THE RVDT (6).

MOXON RVDTs:

THE RVDT IS ASSEMBLED IN A CONTAMINATION CONTROLLED ENVIRONMENT. THE RVDT PARTS ARE CLEANED PRIOR TO ASSEMBLY (1). THE BEARING (8)(9)(10) MATERIALS ARE SELECTED FOR WEAR RESISTANCE (5) TO PREVENT CONTAMINATION GENERATION WITHIN THE SPOOL TUBE. THERE IS NO PHYSICAL CONTACT BETWEEN THE ROTOR AND THE SPOOL TUBE TO GENERATE CONTAMINATION. THE SPOOL TUBE IS ISOLATED FROM THE ACTUATOR HYDRAULICS BY THE ACTUATOR SHAFT SEAL AND A VENT TO DRAIN. THE SPOOL TUBE IS PROTECTED FROM EXTERNAL CONTAMINATION BY A SEAL BETWEEN THE RVDT AND THE ACTUATOR (6).

(1) RC1008, RL10012; (2) 88000342; (3) 88000343; (4) 88000346; (5) RSS-8575; (6) 41003730; (7) 88000300; (8) 104059-2; (9) 104059-3; (10) 104060

Design / Document Reference

FAILURE CAUSE: **D: RVDT: Shaft, drive bar, or pin failure.**

BOTH MOXON AND HYDRAULIC RESEARCH RVDTs ARE USED INTERCHANGEABLY ON THE ACTUATORS. SEPARATE RATIONALE IS PROVIDED UNDER EACH CAUSE. THE HYDRAULIC RESEARCH RVDT INCORPORATES A SHAFT SEAL ON THE ROTOR. THE SEAL IS A DESIGN ENHANCEMENT WHICH PROVIDES ADDITIONAL SPOOL TUBE CONTAMINATION PROTECTION.

HYDRAULIC RESEARCH RVDTs:

THE DRIVE BAR (1) IS 17-4PH COND H1025. THE MATERIAL WAS CHOSEN FOR ITS STRENGTH AND WEAR RESISTANCE. THE MATERIAL IS CORROSION AND STRESS CORROSION RESISTANT (2). THE PIN (3) IS 17-7PH COND CH900. THE MATERIAL WAS SELECTED FOR ITS ELASTIC MODULUS AND STRENGTH. THE MATERIAL IS CORROSION AND STRESS CORROSION RESISTANT (2). THE SHAFT (4) IS MADE FROM 321 CRES AND 4750 NI-FE ALLOY. 321 CRES IS USED FOR ITS WELDING CHARACTERISTICS, RESISTANCE TO CORROSION, AND RESISTANCE TO STRESS CORROSION CRACKING (2). 4750 NI-FE ALLOY IS USED FOR ITS MAGNETIC FIELD RESPONSE AND MATERIAL STRENGTH. THE 4750 NI-FE IS WELDED TO THE 321 CRES TO ASSURE STRUCTURAL CONTINUITY. THE 4 OZ-INCHES MAXIMUM TORQUE REQUIRED TO ROTATE THE RVDT (5) PRECLUDES STRUCTURAL FAILURE OF THE PIN, DRIVE BAR, OR SHAFT.

MOXON RVDTs:

THE DRIVE BAR (6) IS 17-4PH COND H1025. THE MATERIAL WAS CHOSEN FOR ITS STRENGTH AND WEAR RESISTANCE. THE MATERIAL IS CORROSION AND STRESS CORROSION RESISTANT (2). THE PIN (3) IS 17-7PH COND CH900. THE MATERIAL WAS SELECTED FOR ITS ELASTIC MODULUS AND STRENGTH. THE MATERIAL IS CORROSION AND STRESS CORROSION RESISTANT (2). THE SHAFT (7) IS MADE FROM 321 CRES AND 4750 NI-FE ALLOY. 321 CRES IS USED FOR ITS WELDING CHARACTERISTICS, RESISTANCE TO CORROSION, AND RESISTANCE TO STRESS CORROSION CRACKING (2). 4750 NI-FE ALLOY IS USED FOR ITS MAGNETIC FIELD RESPONSE AND MATERIAL STRENGTH. THE 4750 NI-FE IS WELDED TO THE 321 CRES TO ASSURE STRUCTURAL CONTINUITY. THE 4 OZ-INCHES MAXIMUM TORQUE REQUIRED TO ROTATE THE RVDT (8) PRECLUDES STRUCTURAL FAILURE OF THE PIN, DRIVE BAR, OR SHAFT.

(1) 88000317; (2) RSS-8575; (3) 34000448; (4) 88000353; (5) 88000300; (6) 104061; (7) 104062; (8) 104500

FAILURE CAUSE: **E: RVDT: Calibration shift caused by temperature compensation failure.**

BOTH MOXON AND HYDRAULIC RESEARCH RVDTs ARE USED INTERCHANGEABLY ON THE ACTUATORS. SEPARATE RATIONALE IS PROVIDED UNDER EACH CAUSE. THE HYDRAULIC RESEARCH RVDT INCORPORATES A SHAFT SEAL ON THE ROTOR. THE SEAL IS A DESIGN ENHANCEMENT WHICH PROVIDES ADDITIONAL SPOOL TUBE CONTAMINATION PROTECTION.

HYDRAULIC RESEARCH RVDTs:

THE TEMPERATURE COMPENSATORS FOR RVDT CHANNELS A AND B ARE LOCATED ADJACENT TO EACH RVDT ROTOR STATOR SECTION SO AS TO BE EXPOSED TO THE SAME TEMPERATURE (1). THE TEMPERATURE COMPENSATORS (1) ARE DISCRETE UNITS. FAILURE OF ONE UNIT DOES NOT AFFECT THE OTHER. THE COMPENSATOR BOARDS ARE COATED WITH CONFORMAL COATING. THE ELECTRICAL COMPONENTS ARE PROCURED TO EEE ELECTRICAL REQUIREMENTS. THE ELECTRONICS CAVITY IS POTTED TO PREVENT VIBRATION OR MECHANICAL DAMAGE (1).

MOXON RVDTs:

THE TEMPERATURE COMPENSATORS FOR RVDT CHANNELS A AND B ARE LOCATED ADJACENT TO EACH RVDT ROTOR STATOR SECTION SO AS TO BE EXPOSED TO THE SAME TEMPERATURE (2). THE TEMPERATURE COMPENSATORS (2) ARE DISCRETE UNITS. FAILURE OF ONE UNIT DOES NOT AFFECT THE OTHER. THE COMPENSATOR BOARDS ARE COATED WITH CONFORMAL COATING. THE ELECTRICAL COMPONENTS ARE PROCURED TO EEE ELECTRICAL REQUIREMENTS. THE ELECTRONICS CAVITY IS POTTED TO PREVENT VIBRATION OR MECHANICAL DAMAGE (2).

(1) 88000300; (2) 104500

Component Group:	**Actuators**	**Prepared:**	**S. Heater**
CIL Item:	**E120-05**	**Approved:**	**T. Nguyen**
Part Number:	**RES1008-5XXX**	**Approval Date:**	**6/9/00**
Component:	**Main Oxidizer Valve Actuator**	**Change #:**	**1**
FMEA Item:	**E120**	**Directive #:**	**CCBD ME3-01-5624**
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FAILURE CAUSE: ALL CAUSES

HYDRAULIC RESEARCH AND MOXON RVDTs:

THE HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE ACTUATOR MEET CEI REQUIREMENTS (1). THE MINIMUM FACTORS OF SAFETY FOR THE ACTUATOR MEET CEI REQUIREMENTS (2). THE ACTUATOR WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE IT CONTAINS NO FRACTURE CRITICAL PARTS (3). THE ACTUATOR HAS COMPLETED DESIGN VERIFICATION TESTING (4). DVS TEST RESULTS ARE DOCUMENTED (5). THE MOVA FROM ENGINE 2007 WAS DISASSEMBLED AND EXAMINED. NO DETRIMENTAL DEFECTS OR WEAR WERE NOTED. THIS ACTUATOR HAD FIVE FLIGHTS, 14 STARTS, AND 4,210 SECONDS HOT FIRE TIME (6). DURING MAINSTAGE, AN ERRONEOUS RVDT FEEDBACK SIGNAL IS DETECTED BY SEII, OR RVDT NO.1 AND NO.2 COMPARISON LIMIT, OR HPOTP OR HPFTP TURBINE DISCHARGE TEMPERATURE BLUELINE LIMIT (7). THE RESULT OF EXCEEDING ANY OF THE LIMITS IS A CONTROLLER INITIATED HYDRAULIC LOCKUP (8) OF ALL ACTUATORS. AN ERRONEOUS RVDT FEEDBACK SIGNAL MAY ALSO BE DETECTED BY HPFTP TURBINE DISCHARGE TEMPERATURE REDLINE LIMIT (9), WHICH RESULTS IN A CONTROLLER INITIATED ENGINE SHUTDOWN (10). THE SYSTEM IS COMPRISED OF REDUNDANT ACTUATOR POSITION SENSOR ELECTRONICS, REDUNDANT TEMPERATURE SENSORS, REDUNDANT HARNESSES, AND REDUNDANT CONTROLLER CHANNELS.

(1) RL00532, CP320R0003B; (2) RSS-8546, CP320R0003B; (3) NASA TASK 117; (4) DVS-SSME-512; (5) RSS-512; (6) HAS-TM-409; (7) CP406R0002 PT 1 3.2.3:6.1.3, 3.2.3:6.1.4(c); (8) CP406R0002 PT 1 3.2.3:1.7.2; (9) CP406R0002 PT 1 3.2.3:5.3; (10) CP406R0002 PT 2 TABLE XL

SSME FM.. A/CIL
INSPECTION AND TEST

Component Group:	Actuators	Prepared:	S. Heater
CIL Item:	E120-05	Approved:	T. Nguyen
Part Number:	RES1008-5XXX	Approval Date:	6/9/00
Component:	Main Oxidizer Valve Actuator	Change #:	1
FMEA Item:	E120	Directive #:	CCBD ME3-01-5624
Failure Mode:	Erroneous feedback signal.	Page:	1 of 5

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	HYDRAULIC RESEARCH:		
	RVDT COIL MOVA		88000300 88000708 41003730
	COIL WIRE INTEGRITY	COIL MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	88000708
	WIRE PROTECTION	HARNESS WIRE IS VERIFED FILLED WITH POTTING COMPOUND PER DRAWING REQUIREMENTS.	41003730
		COIL WIRE TO LEAD WIRE TERMINATION ENCAPSULATION IN THE RVDT BODY IS VERIFIED PER DRAWING REQUIREMENTS.	88000300
		COIL WINDING IS VERIFIED PER DRAWING REQUIREMENTS.	88000708
	CONTINUITY INTEGRITY	SOLDERED CONNECTIONS ARE VERIFIED PER DRAWING REQUIREMENTS.	88000300
	FUNCTIONAL INTEGRITY	FUNCTIONAL TEST IS VERIFIED PER SPECIFICATION REQUIREMENTS, INCLUDING INSULATION RESISTANCE, DIELECTRIC STRENGTH, COIL RESISTANCE, RVDT CALIBRATION, AND OUTPUT ERROR BAND AND LINEARITY.	RC1008
	MOXON:		
	RVDT COIL MOVA		104500 104082 41003730
	COIL WIRE INTEGRITY	COIL MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	104082
	WIRE PROTECTION	HARNESS WIRE IS VERIFED FILLED WITH POTTING COMPOUND PER DRAWING REQUIREMENTS.	41003730
		COIL WIRE TO LEAD WIRE TERMINATION ENCAPSULATION IN THE RVDT BODY IS VERIFIED PER DRAWING REQUIREMENTS.	104500
		COIL WINDING IS VERIFIED PER DRAWING REQUIREMENTS.	104082
	CONTINUITY INTEGRITY	SOLDERED CONNECTIONS ARE VERIFIED PER DRAWING REQUIREMENTS.	104500
	FUNCTIONAL INTEGRITY	FUNCTIONAL TEST IS VERIFIED PER SPECIFICATION REQUIREMENTS, INCLUDING INSULATION RESISTANCE, DIELECTRIC STRENGTH, COIL RESISTANCE, RVDT CALIBRATION, AND OUTPUT ERROR BAND AND LINEARITY.	RC1008
B	HYDRAULIC RESEARCH:		
	FORWARD BEARING ROTOR ASSEMBLY		88000342 88000340
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	88000342
	BEARING INSTALLATION	BEARING PRELOAD IS INSPECTED PER DRAWING REQUIREMENTS.	88000342
		BEARING RADIAL PLAY IS INSPECTED PER DRAWING REQUIREMENTS.	88000342

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
B	BEARING INSTALLATION	BEARING INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	88000342 88000340
	REAR BEARING ROTOR ASSEMBLY		88000343 88000340
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	88000343
	RADIAL PLAY	RADIAL PLAY IS VERIFIED PER DRAWING REQUIREMENTS.	88000343
	BEARING INSTALLATION	BEARING INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	88000343 88000340
	MID BEARING MID BEARING INSTALLATION		88000346 88000344
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	88000346
	SURFACE FINISH	SURFACE FINISH IS VERIFIED PER DRAWING REQUIREMENTS.	88000346
	BEARING INSTALLATION	BEARING INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	88000344
	MOXON:		
	FORWARD BEARING ROTOR SUBASSEMBLY		104059-3 104059
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	104059-3
	BEARING INSTALLATION	BEARING PRELOAD IS INSPECTED PER DRAWING REQUIREMENTS.	104059-3
		BEARING RADIAL PLAY IS INSPECTED PER DRAWING REQUIREMENTS.	104059-3
		BEARING INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	104059-3 104059
	REAR BEARING ROTOR SUBASSEMBLY		104059-2 104059
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	104059-2
	RADIAL PLAY	RADIAL PLAY IS VERIFIED PER DRAWING REQUIREMENTS.	104059-2
	BEARING INSTALLATION	BEARING INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	104059-2 104059
	MID BEARING ROTOR SUBASSEMBLY		104060 104059
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	104060
	SURFACE FINISH	SURFACE FINISH IS VERIFIED PER DRAWING REQUIREMENTS.	104060
	BEARING INSTALLATION	BEARING INSTALLATION IS VERIFIED PER DRAWING REQUIREMENTS.	104059
C	HYDRAULIC RESEARCH:		

Compone	oup:	Actuators	
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Approved:	T. Nguyen
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
C	COMPONENT CLEANLINESS	COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	88000300
	MOXON:		
	RVDT		
	COMPONENT CLEANLINESS	COMPONENTS ARE VERIFIED TO BE CLEAN PRIOR TO ASSEMBLY.	104500 104500
D	HYDRAULIC RESEARCH:		
	DRIVE BAR PIN ROTOR WELDMENT ROTOR		88000317 34000448 88000353 88000354
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	88000317 34000448 88000353
		THE HEAT TREAT OF THE DRIVE BAR AND PIN IS VERIFIED PER DRAWING REQUIREMENTS.	88000317 34000448
		THE PIN IS MAGNETIC PARTICLE INSPECTED PER DRAWING REQUIREMENTS.	34000448
	WELD INTEGRITY	THE WELDING OF THE SHAFT (ROTOR ASSEMBLY) IS VERIFIED PER WELD REQUIREMENTS. WELD SAMPLES ARE MADE PRIOR TO PRODUCTION WELDS ON SHAFT TO VERIFY WELD PARAMETERS AND SETUP.	RC1008 RA0607-094
		ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	RL10011, RC1008 RA0607-094 RA0115-116 RA0115-006 RA0115-127 RA1115-001
		THE SHAFT ANNEALING AFTER WELDING AND CRUSH ROLLING IS VERIFIED.	88000354
	FUNCTIONAL INTEGRITY	FUNCTIONAL TESTING OF RVDT AND ACTUATOR VERIFIES DRIVE BAR AND PIN OPERATION.	88000317 34000448 88000300
	MOXON:		
	DRIVE BAR PIN ROTOR		104061 34000448 104062
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	104061 34000448 104062
		THE HEAT TREAT OF THE DRIVE BAR AND PIN IS VERIFIED PER DRAWING REQUIREMENTS.	104061 34000448
		THE PIN IS MAGNETIC PARTICLE INSPECTED PER DRAWING REQUIRE...	

Component Group:	**Actuators**	**Prepared:**	**S. Heater**
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
D	WELD INTEGRITY	THE WELDING OF THE SHAFT (ROTOR ASSEMBLY) IS VERIFIED PER WELD REQUIREMENTS. WELD SAMPLES ARE MADE PRIOR TO PRODUCTION WELDS ON SHAFT TO VERIFY WELD PARAMETERS AND SETUP.	RC1008 RA0607-094
		ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	RL10011, RC1008 RA0607-094 RA0115-116 RA0115-006 RA0115-127 RA1115-001
		THE SHAFT ANNEALING AFTER WELDING IS VERIFIED.	104062
	FUNCTIONAL INTEGRITY	FUNCTIONAL TESTING OF RVDT AND ACTUATOR VERIFIES DRIVE BAR AND PIN OPERATION.	104061 34000448 104500
E	HYDRAULIC RESEARCH:		
	CALIBRATION SUBASSEMBLY RVDT		88000325 88000300
	ELECTRICAL INTEGRITY	SOLDERING OF RVDT ELECTRONICS IS INSPECTED.	RC1008
		ENCAPSULATION POTTING IS INSPECTED TO MEET DRAWING REQUIREMENTS.	88000325
		MULTIPLE THERMAL GRADIENT AND THERMAL EQUILIBRIUM TESTS ARE PERFORMED DURING MANUFACTURING. THERMAL GRADIENT AND THERMAL EQUILIBRIUM FUNCTIONAL TESTS VERIFY TEMPERATURE COMPENSATION OPERATION.	88000300
		RVDT CALIBRATION TESTS VERIFY TEMPERATURE COMPENSATION ELECTRICAL INTEGRITY.	RC1008
	MOXON:		
	CALIBRATION SUBASSEMBLY RVDT		104505 104500
	ELECTRICAL INTEGRITY	SOLDERING OF RVDT ELECTRONICS IS INSPECTED.	RC1008
		ENCAPSULATION POTTING IS INSPECTED TO MEET DRAWING REQUIREMENTS.	104505
		MULTIPLE THERMAL GRADIENT AND THERMAL EQUILIBRIUM TESTS ARE PERFORMED DURING MANUFACTURING. THERMAL GRADIENT AND THERMAL EQUILIBRIUM FUNCTIONAL TESTS VERIFY TEMPERATURE COMPENSATION OPERATION.	104500
		RVDT CALIBRATION TESTS VERIFY TEMPERATURE COMPENSATION ELECTRICAL INTEGRITY.	RC1008
ALL CAUSES	HYDRAULIC RESEARCH & MOXON:		
	COMPONENT CLEANLINESS	ALL ACTUATOR DETAILS ARE VERIFIED TO BE CLEAN PRIOR TO INSTALLATION.	RC1008, RL10012

Compone. oup:	Actuators	Prepared:	S. Hea
CIL Item:	E120-05	Approved:	T. Nguyen
Part Number:	RES1008-5XXX	Approval Date:	6/9/00
Component:	Main Oxidizer Valve Actuator	Change #:	1
FMEA Item:	E120	Directive #:	CCBD ME3-01-5624
Failure Mode:	Erroneous feedback signal.	Page:	5 of 5

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	FUNCTIONAL INTEGRITY	HOTFIRE TESTING AND SECOND E & M INSPECTIONS VERIFY SATISFACTORY OPERATION.	RL00050-04 RL00056-06 RL00056-07
		ACTUATOR OPERATION IS VERIFIED PRIOR TO EACH FLIGHT DURING HYDRAULIC SYSTEM CONDITIONING.	OMRSD S00FA0.211
		ACTUATOR OPERATION IS VERIFIED DURING FLIGHT READINESS CHECKOUT PRIOR TO EACH FLIGHT.	OMRSD V41AS0.030
		ACTUATOR OPERATION IS VERIFIED DURING THE ACTUATOR CHECKOUT MODULE PRIOR TO EACH FLIGHT.	OMRSD V41AS0.010
		ACTUATOR POSITION SHIFT BETWEEN PURGE SEQUENCE 3 AND PURGE SEQUENCE 4 IS VERIFIED AS PART OF LAUNCH COMMIT CRITERIA. (LAST TEST)	JSC 16007

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09761.

Operational Use: FAILURE MODE CAN BE DETECTED IN REALTIME BY THE FLIGHT CONTROL TEAM WHO WILL EVALUATE EFFECTS UPON VEHICLE PERFORMANCE AND ABORT CAPABILITY. BASED ON THIS EVALUATION THE APPROPRIATE ABORT MODE OR SYSTEM CONFIGURATION WILL BE SELECTED. FAILURE DETECTION CUES AND ASSOCIATED SSME PERFORMANCE DATA HAVE BEEN COORDINATED BETWEEN THE ENGINEERING AND FLIGHT OPERATIONS ORGANIZATIONS WITH THE RESPONSES DOCUMENTED IN MISSION FLIGHT RULES.