SSME FMEA/CIL
REDUNDANCY SCREEN

Component Group:	Actuators	Prepared:	S. Heater
CIL Item:	E110-13	Approved:	T. Nguyen
Part Number:	RES1008-8XXX	Approval Date:	6/9/00
Component:	Main Fuel Valve Actuator	Change #:	1
FMEA Item:	E110	Directive #:	CCBD ME3-01-5624
Failure Mode:	Pneumatic shutdown piston leakage.	Page:	1 of 1

Phase	Failure / Effect Description	Criticality Hazard Reference
PCD 4.1	Contamination of hydraulic return fluid with helium gas. Loss of vehicle due to loss of hydraulic control of orbiter control surfaces during re-entry.	1 ME-G1P,S,M,C,D
	Redundancy Screens: SINGLE POINT FAILURE: N/A.	

SSME FMEA/CIL DESIGN

Component Group:	Actuators	Prepared:	S. Heater
CIL Item:	E110-13	Approved:	T. Nguyen
Part Number:	RES1008-8XXX	Approval Date:	6/9/00
Component:	Main Fuel Valve Actuator	Change #:	1
FMEA Item:	E110	Directive #:	CCBD ME3-01-5624
Failure Mode:	Pneumatic shutdown piston leakage.	Page:	1 of 1

Design / Document Reference

FAILURE CAUSE: A: Damaged pneumatic piston seals.

THE PNEUMATIC SHUTDOWN ASSEMBLY INCORPORATES DUAL PISTON SEALS WITH A VENT BETWEEN THEM TO PREVENT LEAKAGES PAST THE FIRST SEAL FROM CONTINUING PAST THE SECOND SEAL. THE PISTON SEAL DESIGN INCORPORATES A BUNA-N O-RING (1) WITH A TEFLON RING (2) BETWEEN THE O-RING AND THE PISTON. THE BUNA-N O-RING PROVIDES PRESSURE ACTUATION OF THE SEAL, AND THE TEFLON RING PROVIDES LOW FRICTION WEAR RESISTANT CONTACT WITH THE PISTON (3). THE PNEUMATIC PISTON O.D. (4) IS HARD ANODIZED, AND THE SURFACE FINISHES ARE MACHINED FOR DYNAMIC SEALS TO PREVENT WEAR WHICH MAY DAMAGE THE SEALS. THE HARD ANODIZE ALSO PREVENTS CORROSION AND PRECLUDES DAMAGE CAUSED BY CORROSION PRODUCTS ON THE DYNAMIC SEALING SURFACES. THE PISTON L/D IS 3 WHICH MINIMIZES THE POTENTIAL OF DAMAGE TO THE SEAL CAUSED BY PISTON COCKING. ALL ACTUATOR PARTS ARE CLEANED PRIOR TO ASSEMBLY AND THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (5). THE CLEANLINESS OF THE PNEUMATIC AND HYDRAULIC FLUIDS ARE CONTROLLED (5).

(1) MS28775; (2) S13077; (3) RSS-8576; (4) 34000262; (5) RC1008

FAILURE CAUSE: B: Damaged pneumatic piston.

THE PNEUMATIC PISTON IS MADE FROM 2024-T6 ALUMINUM ALLOY (1). THE MATERIAL WAS SELECTED FOR ITS STRENGTH AND THERMAL COMPATIBILITY WITH THE PNEUMATIC CYLINDER AND ACTUATOR HOUSING. THE MATERIAL IS STRESS CORROSION RESISTANT AND IS ANODIZED FOR GENERAL CORROSION RESISTANCE (2). THE PISTON OUTSIDE DIAMETER IS HARD ANODIZED FOR PROTECTION AGAINST WEAR AND DAMAGE. THE L/D GREATER THAN 3 FOR THE PISTON PREVENTS DAMAGE CAUSED BY COCKING. ALL ACTUATOR PARTS ARE CLEANED PRIOR TO ASSEMBLY AND THE ACTUATOR IS ASSEMBLED IN A CONTAMINATION CONTROLLED AREA (3). THE CLEANLINESS OF THE PNEUMATIC AND HYDRAULIC FLUIDS ARE CONTROLLED (3).

(1) 34000262; (2) RSS-8576; (3) RC1008, RL10012

FAILURE CAUSE: ALL CAUSES

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 MFVA FROM ENGINE 2010 WAS DISASSEMBLED AND EXAMINED. THE ACTUATOR SHOWED NO DETRIMENTAL DEFECTS OR WEAR. THIS ACTUATOR HAD 10,332 SECONDS OF HOT FIRE TIME WITH 28 STARTS, INCLUDING 6,651 SECONDS AT FPL (6).

(1) RL00532, CP320R0003B; (2) RSS-8546, CP320R0003B; (3) NASA TASK 117; (4) DVS-SSME-512; (5) RSS-512; (6) SSME-82-2316

SSME FM.. ./CIL
INSPECTION AND TEST

Component Group: Actuators
CIL Item: E110-13
Part Number: RES1008-8XXX
Component: Main Fuel Valve Actuator
FMEA Item: E110
Failure Mode: Pneumatic shutdown piston leakage.

Prepared: S. Heater
Approved: T. Nguyen
Approval Date: 6/9/00
Change #: 1
Directive #: CCBD ME3-01-5624

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	PISTON PNEUMATIC CAP		34000262 41004165
	SEALING SURFACE INTEGRITY	THE PNEUMATIC PISTON HARD ANODIZE IS VERIFIED PER DRAWING REQUIREMENTS.	34000262
		THE PISTON AND CAP ARE PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	34000262 41004165
		THE SURFACE FINISH OF PNEUMATIC PISTON IS INSPECTED.	34000262
	O-RING/CAP SEAL ASSEMBLY	THE O-RING/CAP SEAL SURFACE IS INSPECTED DURING ASSEMBLY.	RC1008
		PISTON AND CAP ASSEMBLY CLEANLINESS IS VERIFIED PER DRAWING REQUIREMENTS.	RC1008 RL10012
		COMPONENT ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008 RL10012
		FUNCTIONAL TESTING VERIFIES PNEUMATIC PISTON OPERATION.	RC1008
B	PISTON		34000262
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	34000262
		PISTON IS PENETRANT INSPECTED PER DRAWING REQUIREMENTS.	34000262
		ANODIZE AND HARD ANODIZE OF PISTON IS VERIFIED PER DRAWING REQUIREMENTS.	34000262
		THE SURFACE FINISH OF PNEUMATIC PISTON IS INSPECTED.	34000262
		PISTON AND CAP ASSEMBLY CLEANLINESS IS VERIFIED PER DRAWING REQUIREMENTS.	RC1008 RL10012
		COMPONENT ASSEMBLY IS VERIFIED TO BE IN A CONTAMINATION CONTROLLED AREA.	RC1008 RL10012
		FUNCTIONAL TESTING VERIFIES PNEUMATIC PISTON OPERATION.	RC1008
ALL CAUSES	COMPONENT CLEANLINESS	ALL ACTUATOR DETAILS ARE VERIFIED TO BE CLEAN PRIOR TO INSTALLATION.	RC1008, RL10012
	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
		PNEUMATIC SEALS ARE LEAK TESTED PRIOR TO EACH FLIGHT.	OMRSD V41BQ0.170
		ACTUATOR OPERATION IS VERIFIED DURING THE ACTUATOR CHECKOUT MODULE PROBE	

Component Group:	**Actuators**	**Prepared:**	**S. Heater**
CIL Item:	**E110-13**	**Approved:**	**T. Nguyen**
Part Number:	**RES1008-8XXX**	**Approval Date:**	**6/9/00**
Component:	**Main Fuel Valve Actuator**	**Change #:**	**1**
FMEA Item:	**E110**	**Directive #:**	**CCBD ME3-01-5624**
Failure Mode:	**Pneumatic shutdown piston leakage.**	**Page:**	**2 of 2**

Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	FUNCTIONAL INTEGRITY	ACTUATOR OPERATION IS VERIFIED DURING FLIGHT READINESS CHECKOUT PRIOR TO EACH FLIGHT. (LAST TEST)	OMRSD V41AS0.030

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: Not Applicable.

SSME FMEA/CIL
FIELD CONFIGURATION VARIANCES FROM CIL RATIONALE

Component Group: Actuators
Item Name: Main Fuel Valve Actuator
Item Number: E110
Part Number: RES1008-8XXX

Prepared: S. Heater
Approved: T. Nguyen
Approval Date: 6/9/00
Change #: 1
Directive #: CCBD ME3-01-5624

Base Line Rationale	Variance	Change Rationale	Variant Dash Number
1. E110-01, E110-04, E110-07 SHUTTLE AND BYPASS VALVE OPERATIONS ARE VERIFIED PER SPECIFICATION REQUIREMENTS (RC1008).	SOME ACTUATORS ARE USING THE NON-ANTI-ROTATION SHUTTLE AND BYPASS VALVE DESIGN.	THE NON-ANTI-ROTATION SHUTTLE AND BYPASS VALVE DESIGN IS MORE SUSCEPTIBLE TO GALLING. THE NEW DESIGN ADDED THE ANTI-ROTATION FEATURE, PRESSURE BALANCE AND USES CRES 440C MICRO-MELT (VERSUS 440C) TO MANUFACTURE THE SPOOLS AND SLEEVES. THE BYPASS VALVE FILTER ASSEMBLY WAS REPLACED WITH THE NEW SKIRT FILTER DESIGN. THIS DESIGN MINIMIZES THE POSSIBILITY OF SHUTTLE OR BYPASS VALVE GALLING. USE AS IS RATIONALE: 1. THE BYPASS VALVE AND SHUTTLE VALVE ASSEMBLIES ARE THRESHOLD TESTED PER DRAWING REQUIREMENTS. RISK ASSESSMENT OF THE NON-ANTI ROTATION SHUTTLE AND BYPASS VALVE INDICATE THAT THE LIKELIHOOD OF A CRITICALITY 1 FAILURE DUE TO A GALLED BYPASS VALVE (WORST CASE) IS EXTREMELY LOW AND THEREFORE THERE ARE NO CURRENT AND FUTURE USAGE LIMITIATIONS.	P/N 34000137 -102 P/N 41004171 -107, -108