National Aeronautics and
Space Administration

JSC 14651

Lyndon B. Johnson Space Center
Houston, Texas 77058

ORBITER SUBSYSTEM

HARDWARE/SOFTWARE INTERACTION ANALYSIS

VOLUME VIII: AFT REACTION CONTROL SYSTEM

PART 2

JANUARY 1980.

PREFACE

The Orbiter subsystem hardware/software interaction analysis examines software interaction with hardware failure modes. Each failure mode identified in subsystem FMEA (failure mode and effects analysis) is examined for interaction with software. The analysis is based upon key questions which identify potential issues. These potential issues are to be resolved by providing rationale for retention or identifying and implementing changes to eliminate the issue.

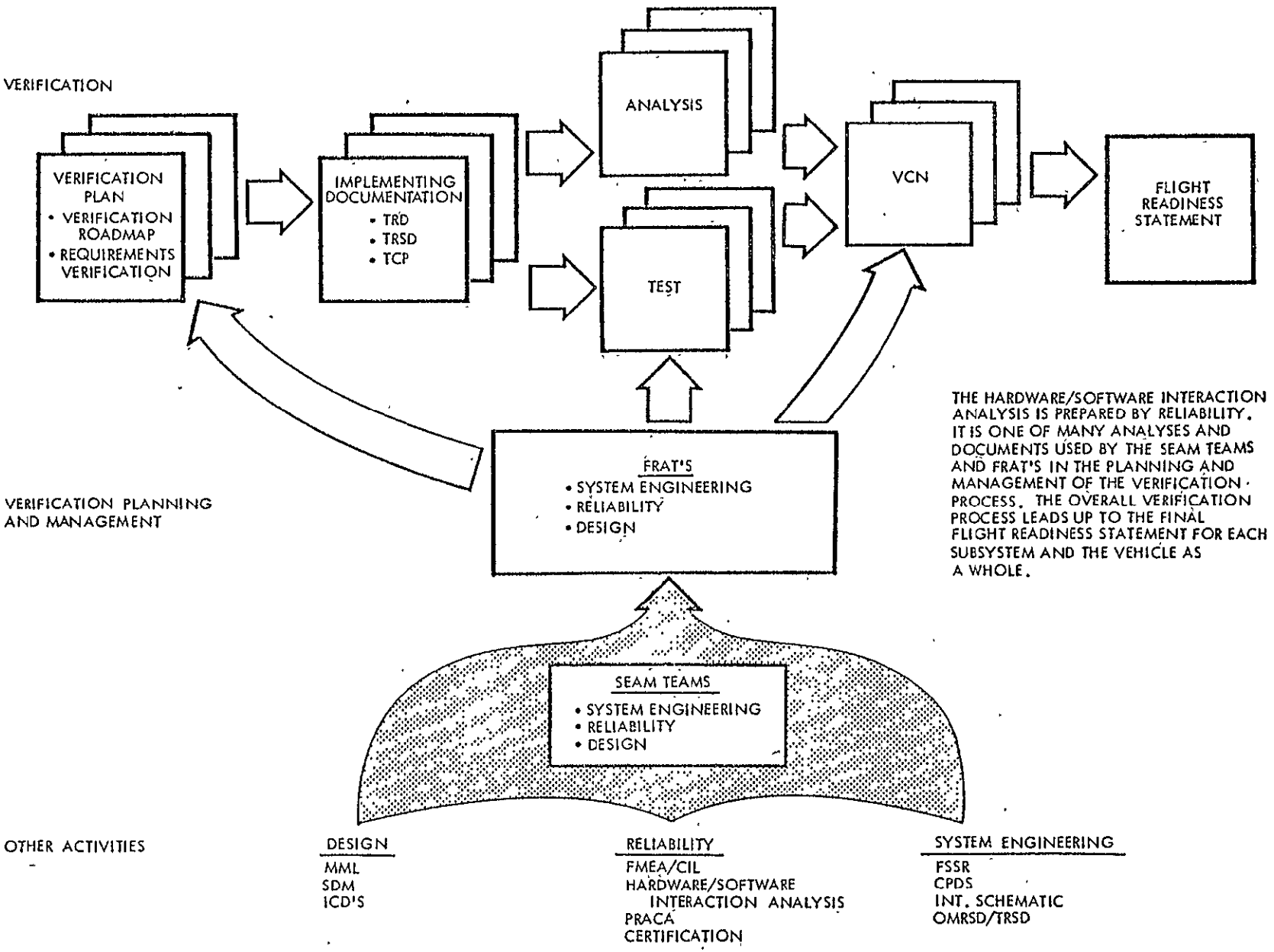
The figure on the following page illustrates the relationship of the hardware/software interaction analysis to the verification process which leads to the statement of flight readiness. As shown, the analysis is a supporting item which is a portion of the data base utilized by the FRAT's (flight readiness assessment teams) and the associated SEAM (Systems Engineering Assessment Meeting) teams in planning and controlling the verification process. The overall issue of hardware/software interface compatibility is addressed by the verification process itself. The analysis scope is limited to examination of single failure modes, as identified in the FMEA, and the interaction of these failure modes with the software as reflected by the software requirements.

The hardware/software interaction analysis is performed on a preliminary basis by the JSC Reliability Division. Results are then coordinated with JSC engineering and Rockwell/Space Systems Group engineering and reliability to obtain inputs and approval signatures. The approval sheet for the AFT Reaction Control System are presented below. The Rockwell signatures represent their review of the open issues and risks, if any, performed against the summarization of the analysis. Section 5.0 presents the analysis summary which groups the failure modes by similar retention rationale and is a convenience in identifying groups of failure modes in which the analysis is similar. The reviews with Rockwell did not cover each checklist. The minutes presented in the appendix document the nature and depth of the Rockwell analysis review.

This analysis verified that no open issues remain. NB

Approved: Joseph H. Levine 11/14/80

Joseph H. Levine
Chief, Reliability Division


VERIFICATION
VERIFICATION PLAN
• VERIFICATION ROADMAP
• REQUIREMENTS VERIFICATION
IMPLEMENTING DOCUMENTATION
• TRD
• TRSD
• TCP
ANALYSIS
TEST
VCN
FLIGHT READINESS STATEMENT
FRAT'S
• SYSTEM ENGINEERING
• RELIABILITY
• DESIGN
VERIFICATION PLANNING AND MANAGEMENT
THE HARDWARE/SOFTWARE INTERACTION ANALYSIS IS PREPARED BY RELIABILITY. IT IS ONE OF MANY ANALYSES AND DOCUMENTS USED BY THE SEAM TEAMS AND FRAT'S IN THE PLANNING AND MANAGEMENT OF THE VERIFICATION PROCESS. THE OVERALL VERIFICATION PROCESS LEADS UP TO THE FINAL FLIGHT READINESS STATEMENT FOR EACH SUBSYSTEM AND THE VEHICLE AS A WHOLE.
SEAM TEAMS
• SYSTEM ENGINEERING
• RELIABILITY
• DESIGN
OTHER ACTIVITIES
DESIGN
MML
SDM
ICD'S
RELIABILITY
FMEA/CIL
HARDWARE/SOFTWARE INTERACTION ANALYSIS
PRACA
CERTIFICATION
SYSTEM ENGINEERING
FSSR
CPDS
INT. SCHEMATIC
OMRSD/TRSD

HARDWARE/SOFTWARE INTERACTION ANALYSIS

AFT - RCS
SUBSYSTEM

FMEA # SD72-SH-0103-2

ANALYSIS DATE November 5, 1979

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1.0 INTRODUCTION. This report documents the results of the analysis of the hardware/software interaction analysis for the AFT Reaction Control System. This analysis examines the interaction between hardware failure modes and software in order to identify associated issues/risks. These issues/risks are resolved through changes to software requirements to remove them, or surfaced to project/program management with appropriate retention rationale.

2.0 SCOPE. All Orbiter subsystems and interfacing program elements which interact with the Orbiter computer flight software are analyzed. The analysis for each subsystem or interfacing element is presented in a separate volume of this report (see section 3.1).

The analysis examines failure modes identified in the subsystem/element FMEA (failure mode and effects analysis). Potential interaction with software is examined through evaluation of the software requirements, not detailed implementation. The analysis is restricted to flight software requirements only, and excludes utility/checkout software. The BFS (backup flight system) software is considered only as necessary, and only as it differs from the primary; the basic thrust of the analysis is keyed to the primary system.

The analysis is based upon the hardware design and software requirements as they existed as of the date of the analysis. Future updates will be published as necessary to incorporate changes to either the hardware or software.

3.0 APPLICABLE DOCUMENTS.

3.1 HARDWARE/SOFTWARE INTERACTION ANALYSIS REPORT VOLUMES. The hardware/software interaction analysis results are reported on a subsystem basis, each in a separate volume. The separate volumes which make up this report are as follows:

Volume	Subsystem
I	Purge, Vent, and Drain
II	Payload Deployment and Retention
III	Payload Bay Doors
IV	Main Propulsion
V	Data Processing Subsystem
VI	Hydraulics
VII	Auxiliary Power Unit
VIII	Reaction Control
IX	Electrical Power Generation
X	Orbital Maneuvering
XI	Environmental Control and Life Support
XII	Integrated Avionics
XIII	Electrical Power Distribution & Control
XIV	GNC (Guidance, Navigation & Control) Support
XV	Displays & Controls
XVI	Communications & Tracking
XVII	Instrumentation

3.2 REFERENCE DOCUMENTS. The primary documents used in performing the analysis included the following:

a. SD75-SH-17A, "Failure Mode Effects Analysis, AFT Reaction Control Subsystem," July 18, 1977.

b. JSC 11174, "OV-102 Space Shuttle Systems Handbook," September 22, 1977.

c. SD76-SH-0026A, "Functional Subsystem Software Requirements, Sequence Requirements," March, 1978.

d. SD76-SH-0020, "Functional Subsystem Software Requirements, Displays and Controls," February 1, 1978.

e. SD76-SH-0027D, "Functional Subsystem Software Requirements, Systems Management," October 16, 1978.

f. MG038103, "Backup Flight System Management/Special Processes and Sequencing Program Requirements Document," December 20, 1978.

g. SD76-SH-0010E "Functional Subsystem Software Requirements, Redundancy Management," June 1, 1979.

4.0 DESCRIPTION.

4.1 GROUND RULES. The hardware software analysis is performed according to the following ground rules:

a. The hardware/software analysis will be limited to investigating the software interaction with the failure modes of the hardware as delineated in the subsystem FMEA's.

b. Software interaction will be limited to involvement of software of the onboard computers.

c. Only failure modes of hardware with software interfaces (software monitoring and/or software control) are analyzed.

d. The software detection must be considered with respect to each phase of the mission [prelaunch (OPS 1 only), ascent, onorbit, and entry].

4.2 ANALYSIS CHECKLIST. The basic tool for the analysis is the checklist (figure 4-1). A separate checklist is used for each failure mode analyzed. Note that the "FMEA Number" in the heading refers to the FMEA document number, not the page number on which the failure mode is treated.

The checklist consists of three sections: Body, change/retention rationale summary, and explanation/comments. Each of these sections is dicussed below.

4.2.1 CHECKLIST BODY. The checklist body contains the questions which drive the analysis. Blocks representing the possible answers for each question are provided. Those answers identified by asterisks entail potential issues and require explanation.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST

SUBSYSTEM _____ FMEA NUMBER _____

ITEM _____ FAILURE MODE _____

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES ☐ NO ☐
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES ☐ NO ☐
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES ☐ *NO ☐
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES ☐ NO ☐
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES ☐ NO ☐
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES ☐ NO ☐
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES ☐ NO ☐
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 ☐ *1 ☐ 2 ☐
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A ☐ YES ☐ NO ☐
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES ☐ *NO ☐
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES ☐ *NO ☐

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. ☐ NO H/S ISSUES
2. ☐ HARDWARE ACCEPTS RISK
3. ☐ NO SOFTWARE DETECTION
4. ☐ DETECTION DURING CHECKOUT
5. ☐ ACCEPTANCE RATIONALE BELOW
6. ☐ RECOMMENDED CHANGES BELOW

☐ FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

Figure 4-1. Hardware/Software Analysis Checklist

The questions in the checklist body are answered using the following guidelines:

a. Question 1. Will the information provided to the onboard software and the processing of that information cause annunciation of the failure and/or initiation of a corrective action in response to this failure mode?

b. Question 1a. Answer question 1a. if the answer to question 1 is "no." Information available to the software could be in the form of (1) sensor data used by onboard software but not for automatic fault detection (data used in software routines or fault detection available through callup or dedicated displays); (2) system and/or subsystem performance parameters; or (3) measurements which are downlisted. Answer "yes" if such information could be used to annunciate the failure condition or initiate responsive action. In explanation comments, specifically identify the information available for software detection.

c. Question 2. If all of the following questions are answered "no," check the "no" block and explain the difference in the explanation/comments section:

(1) Are the master measurements listed under "Failure Detectability In-flight" on the FMEA (1) used by the onboard software in detecting time critical failures (if routed to GPC), or (2) used by the onboard software in annunciating non-time critical failures via callup displays, or (3) downlisted for non-time critical failures?

(2) Are other measurements, dedicated displays, crew detection, and system/subsystem parameters available or able to detect this failure mode?

(3) If "failure detectability in-flight" specifies only software action, does the software actually initiate the corrective action as called out in the "corrective action" portion of the FMEA?

d. Question 3. The question considers only the cases wherein the software determines a failure.

e. Question 3a. Answer question 3a if the answer to 3 is "no." If the answer to 3a is "yes," call out the possible corrective action in the explanation/comments section.

f. Question 4. The question is considered for both the detected and the undetected failure. The overstress or inducement of another failure may be acceptable action. Overstress by software is improper commands, sequencing, or timing resulting in action exceeding hardware design requirements or exposing hardware to excessive environments.

g. Question 5. The question is considered for both the detected and the undetected failure. Limit adverse effects to effects directly resulting from software commands or subsequent actions resulting from erroneous inputs as a result of the failure.

h. Question 6. The hardware/software may change the method of detection and/or correction after the first or the second failure; consider this in answering the question. Determine if the software will be able to use the

redundance of the hardware. If the hardware/software interaction following the particular failure mode changes the criticality, in comparison to the FMEA, check the box provided in the summary section of the checklist.

i. Question 7. If crew action is not required to respond to the failure, check the "N/A" block. Cues which provide inputs to the crew include but are not limited to cathode-ray tube annunciation, caution and warning, visual cues, audible cues, callup and dedicated displays, subsystem status data, panel meters, etc.

j. Question 8.A and 8.B. Answer these questions only if either question 1 or 3 is "yes."

(1) Question 8.A. Consider that the failure occurs while the vehicle is being flown using the primary system. What will happen if the BFS must be engaged subsequent to the failure? Will the fact that the failure has occurred prevent the BFS from operating properly, under any conditions? A "no" answer is a potential issue (requiring explanation) only if the BFS can normally tolerate the failure (when it occurs during BFS operation).

(2) Question 8.B. Consider that the failure occurs while the vehicle is under BFS control. A "no" answer is an issue (requiring explanation) only if the BFS response differs from that for the primary system.

4.2.2 Change/Retention Rationale Summary. Each failure is assigned to one of six possible groups, based upon the answers obtained in the checklist body. Boxes are provided to indicate the category assigned. Figure 4-2 presents the criteria for group assignment.

A box is also provided to indicate that changes are required to the FMEA. The FMEA evaluation of in-flight detectability is sometimes inaccurate and requires change. In addition, other errors (e.g., incorrect criticality assignment or incorrect evaluation of redundancy screens) are occasionally noted during the analysis and are documented here.

A space is provided to detail acceptance rationale, change recommendations, or suggested FMEA changes. This space may also be used to provide a short general comment to expand the retention rationale grouping.

4.2.3 Explanation/Comments. Each question answered by checking a box identified with an asterisk is discussed in this section. The circumstances for checking a box not identified with an asterisk are discussed, and the rationale for not making such a change is presented, if applicable. This section may also be used to explain, expand, or qualify answers. Each discussion is identified with the corresponding question number.

4.3 ANALYSIS SUMMARY. The analysis results are summarized on the basis of retention rationale grouping and recommended changes/retention rationale. Figure 4-3 depicts the form utilized for this purpose. A particular retention rationale definition, acceptance rationale statement, or recommended change is listed in the left column, with the applicable failure modes listed on the right. The issue/risk is briefly described with acceptance rationale or software requirements change recommendation. The summary provides a basic overview of the total analysis results.

CHANGE/RETENTION RATIONALE

1. NO * CHECKED - NO HARDWARE/SOFTWARE ISSUES ARE APPARENT FROM THE ANALYSIS. SYSTEM IS FAIL OPERATIONAL/FAIL SAFE WITH RESPECT TO THIS FAILURE MODE UNDER CURRENT DESIGN.

2. ONLY * CHECKED ON QUESTION 6 - NO HARDWARE/SOFTWARE ISSUES ARE APPARENT FROM THE ANALYSIS. RISK HAS BEEN ACCEPTED VIA HARDWARE CIL.

3. ONLY * (YES) CHECKED ON QUESTION 1a - NO SOFTWARE DETECTION IS PROVIDED. FAILURE EFFECT IS NOT TIME CRITICAL. FAILURE MAY BE DETECTED BY OTHER MEANS OR FUNCTION IS NOT MISSION/SAFETY CRITICAL.

4. * CHECKED ON QUESTION 3a - * ON 1a MAY OR MAY NOT BE CHECKED - SOFTWARE DOES NOT TAKE CORRECTIVE ACTION FOR FAILURE. FAILURE EFFECT IS NOT TIME CRITICAL. CORRECTIVE ACTION MAY BE INITIATED BY CREW. PLANNED CHECKOUT ACTIVITIES WILL DETECT FAILURE. SYSTEM IS FAIL OPERATIONAL/FAIL SAFE WITHOUT SOFTWARE DETECTION AND CORRECTION.

5. STANDARD RETENTION RATIONALE DOES NOT APPLY. SPECIFIC RETENTION RATIONALE IS SUMMARIZED FOR THIS FAILURE.

6. ISSUES IDENTIFIED AND CHANGES ARE DESIRABLE. SPECIFIC CHANGES ARE SUMMARIZED.

NOTE: DO NOT CONSIDER ANSWER TO QUESTION 2 IN DETERMINATION OF CHANGE/RETENTION RATIONALE SUMMARY CODE. CONSIDER RESPONSES TO BOTH QUESTION 2 AND 6 IN DETERMINING WHETHER AN FMEA CHANGE IS REQUIRED.

6.0 ANALYSIS CHECKLIST SHEETS

Following are the analysis checklist sheets for each failure mode evaluated.

Figure 4-2. Change/Retention Rationale

HARDWARE/SOFTWARE ANALYSIS SUMMARY

SUBSYSTEM _____ FMEA

ANALYSIS RESULT	ITEM/FAILURE MODE

Figure 4-3. Hardware/Software Analysis Summary

The subsystem failure modes not analyzed are also identified. These failure modes were evaluated as having hardware/software interfaces. Figure 4-4 depicts the form utilized for this purpose.

5.0 ANALYSIS SUMMARY SHEETS. The analysis results are summarized on the following sheets. The failure modes have been grouped by issue/retention rationale (or change), affording an overview of the results for the entire subsystem.

FAILURE MODES NOT INCLUDED IN HARDWARE/SOFTWARE ANALYSIS
EVALUATED AS INVOLVING NO HARDWARE/SOFTWARE INTERFACE

SUBSYSTEM _____ FMEA _____

ITEM	FAILURE MODE
Failure modes analyzed included only those items currently on the critical items list. All other failure modes will be analyzed at a future date.	

Figure 4-4. Failure Modes Not Included In Hardware/Software Analysis

HARDWARE/SOFTWARE ANALYSIS SUMMARY

SUBSYSTEM AFT - RCS

FMEA SD72-SH-0103-2

ANALYSIS RESULT	ITEM/FAILURE MODE
HARDWARE ACCEPTS RISK	Helium Tank - External Leak (03-2A-201010-1)
	Helium Feed Line - External Leakage (03-2A-201013-1)
	D. C. Solenoid Valve, Helium - Fails Closed (03-2A-201020-1)
	Line, Low Pressure Helium - External Leak (03-2A-201035-1)
	Helium Fill Quick Disconnect - Fails Open (03-2A-201070-1)
	Purge Quick Disconnect, Propellant - External Leakage (03-2A-201080-1)
	Test Quick Disconnect - External Leakage (03-2A-201090-1)
	Feedline and Fittings, Fuel - External Leakage (03-2A-202108-1)
	Propellant Fill and Bleed Disconnect - Fails Open (03-2A-202150-1)
	Propellant Tank Assembly - External Leak (03-2A-211110-1)
	Propellant Tank Assembly - Bubbles in Propellant (03-2A-211110-2)
	Injection Plate - Restricted Flow (03-2A-221311-1)
	Thrust Chamber - Burn-Thru (03-2A-221312-1)
	Nozzle Extension - Burn-Thru (03-2A-221313-1)
	Vernier Thruster - Loss of Output (03-2A-231310-1)
	Vernier Thruster - Fails to Stop Firing (03-2A-231310-2)
	Vernier Thruster - Burn-Thru (03-2A-231310-3)

HARDWARE/SOFTWARE ANALYSIS SUMMARY

SUBSYSTEM AFT - RCS

FMEA SD72-SH-0103-2

ANALYSIS RESULT	ITEM/FAILURE MODE
DETECTION DURING CHECKOUT	Helium Pressure Regulator - Restricted Flow - Fails Closed (03-2A-201030-2)
	Helium Quad Check Valve - Fails Closed (03-2A-201095-2)
	Feedline and Fittings, OX - External Leakage (03-2A-202109-1)
	Tank Isolation Valve, A. C. - Fails Closed (03-2A-202110-1)
	Tank Isolation Valve, A. C. - Fails Closed (03-2A-202110-3)
	Interconnect Valve, A. C. - Fails Closed (03-2A-202111-2)
	Manifold Isolation Valve, A. C. - Fails Closed (03-2A-202120-3)
	Manifold Isolation Valve, D. C. - Fails Closed (03-2A-202140-1)
	Gimbal Joint - External Leakage (03-2A-211120-1)
	Bellows Assembly - External Leakage (03-2A-221308-1).
	Engine Inlet Valve - Fails Closed (03-2A-221310-4)

HARDWARE/SOFTWARE ANALYSIS SUMMARY

SUBSYSTEM AFT - RCS

FMEA SD72-SH-0103-2

ANALYSIS RESULT	ITEM/FAILURE MODE
NO SOFTWARE DETECTION	Relief Valve - External Leak - Fails Open (03-2A-201060-4)

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201010-1

ITEM He Tank FAILURE MODE External Leak

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [X]	NO [ ]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X]	*1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ]	*NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. V42P3110, 3113 (Right AFT) or V42P2110, 2113 (left AFT) He tank transducers will issue a class 3 alarm, RM GAX blue light on the crew-cockpit glare shield, upon sensing low pressure < 500 psi. Gross leak detection C&W is first indication.

5. A He tank leak will adversely affect the RCS quantity monitor principal function by causing meter M4 (panel O3) "RMS/OMS propellant quantity" to indicate an erroneously low percent quantity remaining. This is because He tank pressure is used in the software calculation. See FSSR 26 "sequencing", principal function 4.102.

6. No redundant tanks - loss of RCS function. Crossfeed is available.

8B. Same as primary.

.SUBSYSTEM: PROP - PROPELLANT SUPPLY
.ITEM: PROPELLANT TANK ASSY
.P/N: 1YXXA-0302-0003/-0007
.S/N: ALL
.QUANTITY: 2
.FAILURE MODE NUMBER: 1
.ACRT:
.MISSION PH: PL
.PHASE(S): PL
.NUMBER OF SUCCESS PATHS REMAINING:
.AFTER 1ST FAILURE:
.TECHNOLOGY SCREEN: Y-N/A N-N/A O-N/A
.FAILURE IS DETECTABLE IN FLIGHT?: YES
.VEHICLE EFFECT:
.TANK PRESSURE MEASUREMENT
.REFERENCE DOCUMENTS:
.IS.
.MSFC-SPEC-106
.FAILURE JUSTIFICATION?.....YES
.VS70-40103
.SUBSYS ABOVE
PROP GAGING SYS
.CG72-SH-CI20-2
.SYSTEM
MJC7X-0001-1E

PREPARED BY: J TAGGART APPROVED BY:
QES QES
REL L AKERS REL

.ITEM: TANK
. PROPELLANT STORAGE, RELATED AGENC
.FAILURE CAUSE(S):
. 1. STORE PROPELLANT AT A MAX WORKING PRESSURE OF 400 PSIA FOR
MISSION DURATION OF THE APOLLO MODULE'S PROPELLANT SUPPLY SYSTEM. TANK
CONSISTS OF TITANIUM LINER WITH GRAPHITE KEVLAR AND FIBERGLASS
OVERWRAP. P.S.D. IS 14.7 IN. WEIGHT IS 300 LBS. EA.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. CATASTROPHIC
.EFFECT(S):
. TOTAL LOSS, LEAK FAIL, BURST FAIL, EPOXY CURE IN DPS, RESIDUAL GAS
SHOCK, VIB, INADVERT OVERPRESS (ONE). INADEQ MOUNTING
.EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF FUNCTION/SUBSYSTEM (B) LOSS OF INTERFACE FUNCTION -
POSSIBILITY OF DEPLETE/UTILIZE PROP, POSSIBLE DAMAGE TO PRC STRUCTURE &
TPS. (C) MISSION MODIFICATION - X-FEED FAIL OMS OR RCS. (D) POSSIBLE
LOSS OF CREW VEHICLE EXCESS RATE OF LEAK MAY EXCEED PRV AT CAPA.
CAUSING DAMAGE TO PRC STRUCT & DEGRAD OF THERMAL PROT SYS. EXCESS
PROPELLANT PRESS MAY ADVERSELY AFFECT VEH DYN DURING ENTRY & LNDG.
.CORRECTING ACTION:
. X-FEED PROP FROM OMS OR RCS. GEL AGE MAY BE ADEQ FOR PROP FEED FROM
FAILED PRC.
.REMARKS/RATIONALE:
. EXCESS RATE OF LEAK MAY EXCEED PRC VENT CAPAB CAUSING DAM TO PRC
STRUCT & DEGRAD OF THERMAL PROT SYS (MOLECULAR VENTING PAST WELD OR
LEAK). EXCESS PRESS OF PROP MAY ADVERSELY AFFECT VEH DYN DURING ENTRY
& LNDG. NO RECORD FOR TANKS. REF HAZ NO 1YXXA-0302-02.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTPOL FMEA NO 03-2A -201010-1 REV:11/08/78
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1
.P/N PI :MC282-0002-0031/-0032 CRIT. HDW: 1
.P/N VENDOR:BLO-999040-1/-2 MISSIONS: NF VF X FF OF SM
.QUANTITY :4 PHASE(S): PL X LO X CO X DO X LS
. :TWO BOTTLES REQ'D PER
. :MODULE:ONE PER PROP. TK.
. REDUNDANCY SCREEN: A-N/A B-N/A C-N/A
.
.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES J TAGGART DES SSM
.REL C AKERS REL REL
.
.
APPROVED WITH CHANGES
See Section 13.0

.ITEM: TANK
. HELIUM STORAGE, FILAMENT WOUND
.FUNCTION:
. TO STORE HELIUM AT A MAX WORKING PRESSURE OF 4000 PSI FOR PRESSURIZATION OF THE AFT RCS MODULE'S PROPELLANT SUPPLY SYSTEM. TANK CONSISTS OF DOUBLE MELT TI LINER WITH DUPONT KEVLAR 49 FIBER AND EPOXY RESIN BONDING OVERWRAP. O.D. IS 18.71 IN. VOLUME IS 3008 CU. IN.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. EXTERNAL LEAK
.CAUSE(S):
. MAT'L DEF, LINER DEF, FAULTY FAB, EPOXY CURE INADEQ, TEST/HANDL DAM, SHOCK, VIB, INADVER OVERPRESS (GND), INADEQ MOUNTING
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF FUNCTION/SUBSYSTEM (B) LOSS OF INTERFACE FUNCTION - INABILITY TO DEPLETE/UTILIZE PROP, POSSIBLE DAMAGE TO POD STRUCTURE & TPS. (C) MISSION MODIFICATION - X-FEED FROM OMS OR RCS. (D) POSSIBLE LOSS OF CREW VEHICLE EXCESS RATE OF LEAK MAY EXCEED POD VENT CAPAB CAUSING DAMAGE TO POD STRUCT & DEGRAD OF THERMAL PROT SYS. EXCESS RETENTION OF PROP MAY ADVERSELY AFFECT VEH DYN. DURING ENTRY & LNDG.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) FILAMENT WOUND TANKS ARE DESIGNED TO LEAK BEFORE RUPTURE WHICH LIMITS FAILURE PROPAGATION DUE TO SHRAPNEL. KEVLAR 49 FIBER HAS A TENSILE STRENGTH OF 500KSI ALLOWING LIGHT WEIGHT WITH GREAT STRENGTH. INCREASED STRAIN CAPABILITY IS PROVIDED BY THE COMPRESSIVE LOAD ON A UNPRESSURIZED LINER. VENT DOORS ARE OPEN ON ORBIT AND WILL RELIVE ANY PRESSURE BUILDUP DUE TO LEAKAGE. THE F.S. (BURST) IS 1.5 X WORKING PRESS. (B) 1000 PRESSURE CYCLES ARE PERFORMED DURING QUAL WHICH IS MORE THAN 4 X ANTICIPATED OPERATING LIFE. A 90-DAY CREEP TEST UNDER PRESSURE IS ALSO PERFORMED AFTER WHICH THE TANK IS EXAMINED TO VERIFY NO PERMANENT DEFORMATION OR FLAW GROWTH. PROOF PRESSURE (1.10 X WORKING PRESSURE) AND LEAKAGE TESTS ARE PERFORMED DURING ATP. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. RAW MAT'L AND PURCHASED COMPONENT REQMTS ARE VERIFIED BY RECEIVING INSP. MEASUREMENT STANDARDS AND TEST EQUIP. STANDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPECS. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSPECTION POINTS - PARTS PROTECTION, MFG. PROCESSES, FINISHES, ASSY AND INSTALLATION. THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 5-23-77 - CORROSION PROTECTION PROVISIONS, TEST HANDLING, AND STORAGE

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201010-L REV:11/03/7?
ENVIRONMENTS. TENSILE, HEAT TREAT AND WELD SAMPLES ARE TESTED DURING IN-PROCESS FABRICATION IN ADDITION TO X-RAY & DYE PENETRANT FOR THE LINES. WIND PATTERN & WINDING CONTROL ARE USED FOR THE KEVLAR FIBER DURING IN-PROCESS MANUFACTURE. WEIGHT CONTROL IS USED FOR THE EPOXY RESIN. TURNAROUND - MONITOR LEAKAGE TESTS PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND AS PART OF THE CHECKOUT PROCEDURE PRIOR TO FLIGHT. PRESSURE CYCLES ACCUMULATED ARE ALSO RECORDED. (0) NONE AVAILABLE NEW DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201013-1

ITEM He Feed Line FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ]	*NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X]	*1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ]	*NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. V42P3110, 3113 (Right AFT) or V42P2110, 2113 (leftAFT) He Tank transducers will issue a class 3 alarm, RM GAX blue light on the crew-cockpit glare shield, upon sensing low pressure < 500 psi. Gross leak detection C&W is first indication.

2. FMEA Change - For "failure detectable in flight" V42P-2110C through 2114C and 3110C through 3114C should be V42P2110C, 2112C, 2112C, 2113C, 2114C and 3110C, 3112C, 3113C 3114C dropping out 2111C and 3111C which do not exist.

6. Feedlinesare criticality 1 with no remaining success paths. Crossfeed is available.

8b. Same as primary.

SPOTTED FAILURE MODE AND EFFECTS ANALYSIS - OR[illegible]

[illegible] - REACTION CONTROL — PHASE NO 02-PA -[illegible] — [illegible]
[illegible] — ABORT: — CRIT. FUNC: [illegible]
[illegible] — CRIT. NO.: [illegible]
[illegible] — MISSIONS: [illegible]
[illegible] — PHASE(S): [illegible]
[illegible] — NUMBER OF SUCCESS PATHS REMAINING
[illegible] — AFTER FIRST FAILURE:
PRELIMINARY SCREEN: [illegible]

FAILURE DETECTABLE IN FLIGHT? YES — TIME TO EFFECT:
IN TANK PRESS IND — VAGR-21100 1PSU 21140 — EFFECTS TO PROPS
INTO TANK PRESS — REFERENCE DOCUMENTS:
M1621-[illegible] (SCHEMATIC)
SPECIAL TURNAROUND?.....YES — VS70-[illegible]
SEE ABOVE — GSE LEAK C/O,VISUAL INSP — SD72-SH-0103-[illegible]
MJ070-0012-[illegible]

PREPARED BY: — APPROVED BY:
JES — N C GLAVINICH — DLS _____
REL — C M AKERS — REL _____

ITEM: HELIUM FEED LINE

FUNCTION:
- 1/2 X .042 CRES TUBE S.S LINES TO PROVIDE HELIUM FEED PROP HELIUM TANKS TO HELIUM REGULATOR/PRESSURIZATION SYSTEM PANEL

FAILURE MODE: STRUCTURAL FAILURE (S)
- RUPTURE, EXTERNAL LEAKAGE

CAUSE(S):
- MAT'L DEF (SULPHIDE STRINGER), VIB, SHOCK, STRUCT FAIL, FATIGUE, WELD DEF. STRESS CORROS, IMP INSTALL.

EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF SUBSYSTEM PRESSURIZATION CAPABILITY IF ACT ISOL (FAIL UPSTREAM OF ISOL VLV-INABILITY TO DEPLETE/UTILIZE PROP). (B) LOSS OF INTERFACE FUNCTION (UNABLE TO REPRESS PROP TANK - POT FOR STRUCT DAM. (C) ABORT (LOSS OF PRESS) (D) POSSIBLE LOSS OF CREW/VEHICLE - IF LEAK EXCESS OR PDL/TPS DAM OCCURS

CORRECTING ACTION:
- [illegible] UTILIZE PROP TANK ULLAGE PRESS & DMS OR RCS PROP X-FEED AS REQ'D. [illegible]

REMARKS/HAZARDS:
- V.R. IYY MAY BE ALVER APP IF SIG QUAN OF PROP REMAINS. PDL OVERPRESS MAY RESULT IN DAM TO STRUCT & TPS. REF HAZ NO IYXX-(302-02.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201013-1 REV:12/13/78
.ASSEMBLY :PRESSURIZATION HELIUM ABORT: CRIT. FUNC: 1
.P/N RI :MC621-0059 CRIT. HDW: 1
.P/N VENDOR:73A630000 MISSIONS: HF VF X FF OF SM
.QUANTITY :4 PHASE(S): PL X LO X OO X DO X LS X
. :ONE SET PER PROPELLANT
. :PER MODULE
. REDUNDANCY SCREEN: A-N/A B-N/A C-N/A
.
.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES N C GLAVINICH DES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: HELIUM FEED LINE
.
.FUNCTION:
. 1/2 X .042 304L S.S LINES TO PROVIDE HELIUM FEED FROM HELIUM TANKS TO HELIUM REGULATION/PRESSURIZATION SYSTEM PANEL
.FAILURE MODE: STRUCTURAL FAILURE (S)
. RUPTURE, EXTERNAL LEAKAGE
.CAUSE(S):
. MAT'L DEF (SULPHIDE STRINGER), VIB, SHOCK, STRUCT FAIL, FATIGUE, WELD DEF, STRESS CORROS, IMP INSTALL.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF SUBSYSTEM PRESSURIZATION CAPABILITY IF NOT ISOL (FAIL UPSTREAM OF ISOL VLV-INABILITY TO DEPLETE/UTILIZE PROP). (B) LOSS OF INTERFACE FUNCTION (INABIL TO REPRESS PROP TANK - POT POD STRUCT & TPS DAM. (C) ABORT DECISION (LOSS OF PRESS) (D) POSSIBLE LOSS OF CREW/VEHICLE - IF LEAK EXCESS OR POD/TPS DAM OCCURS
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 1.5 TO 4.0 MAXIMUM OPERATING PRESSURE (SYSTEM RELIEF). THE WELDED CONSTRUCTION ELIMINATES JOINTS AND POSSIBLE LEAK PATHS. THE ANNEALED AREA (DUE TO WELDING) IS BACKED UP BY A SLEEVE. FASTENING CLAMPS ALLOW FREEDOM OF MOVEMENT. TUBING BENDS ARE CONTROLLED BETWEEN FIXED POINTS TO FACILITATE INSTALLATION AND ACCOMMODATE VEHICLE GROWTH AND MOVEMENT. (B) ROCKWELL PERFORMED TUBING CERTIFICATION TESTS PER "ORBITER TUBING VERIFICATION PLAN" (SD 75-SH-0205). THIS TESTING INCLUDED PRESSURE CYCLING AND FOR TYPICAL SHUTTLE LINES & JOINTS. SYSTEM EVALUATION TESTS AT WSTF WILL ALSO ALLOW EVALUATION IN THE INSTALLED SYSTEM CONDITION. LEAKAGE TESTS ARE PERFORMED IN-PROCES FOR TUBING SECTIONS. OPTICAL INSPECTIONS ARE ALSO PERFORMED AT THIS TIME IN ADDITION TO X-RAY AND DYE PENETRANT. LEAKAGE TESTS ARE ALSO PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND ADDITIONAL WELDS ARE ALSO SUBJECTED TO NDE. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAM. CONTROL PROCESSES, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS AND INSP. FOR SURFACE AND SUB-SURFACE DEFECTS IS VERIFIED BY INSPECTION. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELEER MANDATORY INSP. POINTS. RAW MAT'L (LOT CERTIFICATION), PARTS PROTECTION, MANUF., COATING, PLATING, INSTLLATION AND ASSEMBLE OPERATIONS. HARDWARE IS INSP. IN ACCORDANCE WITH QUALITY PLANNING REQMTS DOCUMENT (QPRD) WHICH HAS BEEN APPROVED BY NASA.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201013-1 REV:12/13/7S
TURNAROUND - LINES IN ACCESSIBLE AREAS ARE VISUALLY INSPECTED FOR EVIDENCE OF DAMAGE AND FLOW AND PRESSURE FUNCTIONAL TESTS ARE MONITORED FOR EVIDENCE OF OBSTRUCTION OR LEAKAGE. (C) MINOR HISTORY - CORROSION/FAB PROBLEMS DETECTED DURING APOLLO CHECKOUT AND CORRECTED.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201020-1

ITEM D.C. Solenoid Valve, He FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [X]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ]	*NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [XX]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

See Note 2.

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Ullage transducer will give C&W alert < 200 psi.

2. Measurement numbers V42X2124X, 2126X, 3124X, and 3126X (Fu He isolation valves) needs to be added for detectability since only the measurement stimulus identification numbers for the oxidizer valves are listed now.

SUBSYSTEM: RCS - [illegible] CONTROL — PAGE NO 13-2A — [illegible] — DATE:12/[illegible]
ASSEMBLY: HPG VALVE/REGULATOR — ALERT: — CRIT. FLAG: 1
P/N: [illegible] — CRIT. NO:
MANUFACTURER: [illegible] — MISSIONS: PP VP A PP OF S
FUNCTION: [illegible] — PHASE(S): PL X LO [illegible] OF S LS
TWO VALVES PROVIDED FOR EACH HELIUM SUPPLY — NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE:
REDUNDANCY SCREEN: A-PASS B-PASS C-[illegible]
FAILURE DETECTABLE IN FLIGHT? YES — TIME TO EFFECT: MINUTES
OPERATION INDICATIONS V42 212-X,2127X,2120X,21[illegible] — REFERENCE DOCUMENTS:
MC 621-0159
V570-431-01
SD72-SH-0103-2
MJ57[illegible]-[illegible]-015
GROUND TURNAROUND?.....YES
SAME AS FLIGHT INSTRUMENTATION

PREPARED BY: — APPROVED BY:
DES K BURKHART — DES _____
REL C M AKERS — REL _____

.TITLE: VALVE, L.C. SOLENOID
. OPERATED, HIGH PRESSURE. HELIUM (3/2) BI-STABLE. (LATCHING - MAGNETIC (SPRING FORCE) LV 201/202/203/204/301/[illegible]
.FUNCTION:
. UTILIZED TO CONTROL HELIUM PRESSURIZATION SYSTEM IN THE APS MODULES. IN THE OPEN POSITION A FLOW PATH IS PROVIDED FROM THE HELIUM SUPPLY TANK(S) TO THE REGULATORS. TWO PARALLEL PATHS ARE PROVIDED FOR EACH PROPELLANT TANK. ONE PATH IS NORMALLY OPEN PER TANK. THE OPEN VALVE MAY BE CLOSED AND THE PARALLEL VALVE OPENED SUBSEQUENT TO A CRYSTAL FAILURE.
.FAILURE MODE: FAILS CLOSED (F)

.CAUSE(S):
. VSL CONTINUOUS INVOLVES CLOSING SIGNAL DUE TO SHORT CIRCUIT, SHOCK, CONNECTOR PIN OR LEAD DAMAGE, JAMMING OF POPPET, PLUGGED ORIFICE.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF REDUNDANCY - PARALLEL PATH AVAILABLE. (B) NO EFFECT.
. (C) ABORT MISSION - DUE TO ONLY ONE PATH REMAINING WHICH IS CRITICAL EFFECT. (D) NO EFFECT. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS - FAILURE OF REDUNDANT PARALLEL FLOW PATH WOULD RESULT IN INABILITY TO BURN OR DUMP/TOP RCS PROPELLANT. THIS WOULD RESULT IN POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO USE RESERVED ENTRY PROPELLANT OR C.G. PROBLEMS RESULTING FROM PROPELLANT WEIGHT.
.CORRECTING ACTION:
. IF CAUSED BY VIBRATION, THE VALVE MAY BE CAPABLE OF OPENING WITH A NEW COMMAND, OR SWITCH TO PARALLEL PATH.
.REMARKS/HAZARDS:
. POTENTIAL TIME CRITICAL HAZARD RELATED TO REACTION TIME FOR SWITCHING TO ALTERNATE PATH DURING CRITICAL MODES OF OPERATION SUCH AS E.I.

[illegible] FAILURE MODE AND EFFECTS ANALYSIS - [illegible]

[illegible]

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-24 -201020-1 REV:12/12/7
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1R
.P/N RI :MC284-0419-0011/-0012 CRIT. HDW: 2
.P/N VENDOR:73835 MISSIONS: HF VF X FF OF SM
.QUANTITY :8 PHASE(S): PL X LO X OO X OO X LS
. :TWO VALVES REQ'D FOR EAC
. :H HELIUM SUPPLY
. REDUNCANCY SCREEN: A-PASS B-PASS C-FAI.
.
.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES R BURKHART DES SSM
.REL C M AKERS REL REL
APPROVED WITH CHANGES
See Section 13.0

.ITEM: VALVE, D.C. SOLENOID
. OPERATED, HIGH PRESSURE. HELIUM (1/2") BI-STABLE. (LATCHING - MAGNETIC & SPRING FORCE) LV 201/202/203/204/301/302/303/304.
.FUNCTION:
. UTILIZED TO CONTROL HELIUM PRESSURIZATION SYSTEM IN THE AFT MODULES. IN THE OPEN POSITION A FLOW PATH IS PROVIDED FROM THE HELIUM SUPPLY TANK(S) TO THE REGULATORS. TWO PARALLEL PATHS ARE PROVIDED FOR EACH PROPELLANT TANK. ONE PATH IS NORMALLY OPEN PER TANK. THE OPEN VALVE MAY BE CLOSED AND THE PARALLEL VALVE OPENED SUBSEQUENT TO A DOWNSTREAM FAILURE.
.FAILURE MODE: FAILS CLOSED (F)
.
.CAUSE(S):
. VIB CONTINUOUS INADVER CLOSING SIGNAL DUE TO SHORT CIRCUIT, SHOCK, CONNECTOR PIN OR DIODE DAMAGE, JAMMING OF POPPET, PLUGGED ORIFICE.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF REDUNDANCY - PARALLEL PATH AVAILABLE. (B) NO EFFECT. (C) ABORT DECISION - DUE TO ONLY ONE PATH REMAINING PRIOR TO CRITICAL EFFECT. (D) NO EFFECT. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW VEHICLE LOSS - FAILURE OF REDUNDANT PARALLEL FLOW PATH WOULD RESULT IN INABILITY TO BURN OR DEPLETE RCS PROPELLANT. THIS WOULD RESULT IN POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO USE RESERVED ENTRY PROPELLANT OR C.G. PROBLEMS RESULTING FROM PROPELLANT WEIGHT.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) PARALLEL VALVES AND REDUNDANT POWER SOURCES ARE PROVIDED. ULLAGE PRESS IS ADEQ FOR PROP FEED WITH LESS THAN 35 PERCENT PROP REMAINING. ONE VALVE IS MAINTAINED IN THE LATCHED OPEN POSITION WITH NO POWER APPLIED & THE OTHER IS LATCHED CLOSED. AN INDUCTIVE VOLTAGE SUPPRESSION CIRCUIT IS PROV IN THE ELECTRICAL SYSTEM TO PREVENT DAMAGE TO OTHER ON-LINE COMP. REDUN DIODES LIMIT THE POSS OF DIODE FAILURE ALLOWING CURRENT SHUNT FROM THE COIL. A 100-MICRON FILTER IS PROV TO LIMIT THE POSS OF CONTAM CAUSING LEAKAGE, JAMMING MOVING PARTS - OR PLUGGING PILOT CONTROL ORIFICES. TO LIMIT THE ELECT SHORT POTENTIAL, THE LEAD AND MAGNET WIRES ARE ENCAP BY POTTING AND A FIXTURE IS USED DURING ASSEMBLY TO ENSURE THAT INSUL IS NOT DAMAGED BY THE EXIT NOTCH WHEN THE COIL SLEEVE IS PRESSED ONTO THE COIL. (B) 4000 OPER CYCLES (ON-OFF-FLOW) AND RANDOM VIB AT ANTIC MISSION LEVELS ARE PERF DURING QUAL. ITEM IS USED

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201020-1 REV:12/12/73
DURING SYS EVAL TESTS AT WSTF ALLOWING EVAL UNDER SIMUL MISSION USAGE COND. PROOF PRESSURE, LEAKAGE, OPER AND INSUL TESTS ARE PERF DURING ATP. APROP LOCATED TEST POINTS ALLOW PRE/POST FLIGHT LEAKAGE TESTS AND OPER TESTS ARE ALSO CONDUCTED AT THIS TIME. (C) AN IDENT IS PERF AND THE UNIT TAGGED. CONTAM CONT PROCESS, CORROS. PROT PROV, NDE EXAM. OF WELDS AND BRAZES, INSP. FOR SURFACE AND SUBSURFACE DEFECTS AND PROPER ELECT TERMINATIONS ARE VERIF BY INSP. THE FOLLOWING ITEMS ARE VERIF BY SHOP TRAVELER MANDATORY INSP. POINTS - RAW MAT'L (LOT CERT), PARTS PROT, MANUF., COATING, PLATING INSTALL AND ASSEMBLY OPER. THE ABOVE ITEMS AND THE FOLL ITEMS WERE VERIF BY AUDIT COND 8-31-77. CONTAM CONT PROCESSES, CORROS. PROT PROV. TURNAROUND - FUNCT FLOW TESTS ARE MONITORED TO VERIFY THAT VALVES OPEN AND CLOSE PROPERLY UPON COMMAND. (D) APOLLO FAILURES WERE MAINLY ASSOC WITH REVERSE POLARITY AND DEGAUSSING OF MAGNETS. THE SHUTTLE VALVE UTILIZES A CONNECTOR (RATHER THAN LEAD WIRES) AND BLOCKING DIODE WHICH PREVENTS THIS TYPE OF ERROR DURING CONN. A POTENT ELECT SHORTING PROB ON A SIMILAR VALVE DUE TO INSUL DAMAGE WAS DISCOV DURING QUAL AND CORR AS DESCRIBED IN ITEM (A) ABOVE.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201030-2

ITEM He Pressure Regulator FAILURE MODE Restricted Flow - Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X] *NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [ ]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Ullage transducer will give C&W alert < 200 psi.

3A. Software could provide automatic switch over to parallel leg.

6. 1 success path remaining after first failure.

7. Cathode-ray tube and downlist is available.

SPACE SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - CRITICAL ITEM

SUBSYSTEM: RCS - REGULATOR CONTROL
ASSY ONLY: PRESSURANT TANK
P/N: 1
P/N VENDOR: MMC/DOD 1
QUANTITY: 4
:TWO PARALLEL MODE
:THREE UNITS PER TANK

FMEA NO 83-RCS-R-[illegible]
ALERT:

MISSIONS: ME
PHASE(S): IE
NUMBER OF SUCCESS PATHS REMAINING
:FIRST POINT FAILURE:

REDUNDANCY SCREENS: A=P/SS 1=P/SS
ITEM: REGULATOR
FAILURE DOCUMENTS:
VS72-H-2001
MJC72-0001-2
SS72-SH-0103-
MC621-0059

CRIT. FUNC:
UNIT. LOC:

FAIL OPERATIONAL IN FLIGHT?. YES
HOW TANK ULLAGE PRESS V42P-[illegible] 3116 3115 3116

SECOND TURNAROUND?.....YES
HOW C/O TEST POINTS

PREPARED BY:
DES G. IKAVIS
REL C. MAKERS

APPROVED BY:
DES _____
REL _____

.ITEM: REGULATOR PRESS, PC
. SERIES REDUNDANT. SET AT UNEQUAL OUTLET PRESSURES (PR
. 1/PRP/2(3/4).
.FUNCTION:
. TO REGULATE STORED HELIUM PRESSURE FROM 4000 PSIG MAX TO ULLAGE PRESSURE OF 240 (+ OR - 3) PSIG FOR PURPOSE OF PROPELLANT FEED TO THRUSTERS. TWO PARALLEL PATHS WITH TWO SERIES REGS ARE PROVIDED FOR EACH PROPELLANT TANK. PRIMARY ELEMENT SET 11 PSI LOWER THAN SECONDARY.
.FAILURE MODE: FAILS CLOSED (F)
. RESTRICTS FLOW.
.CAUSE(S):
. CONTAM (PILOT SCREEN), FROZEN MOIST, SPRING/SEAT FRACTURE, FATIGUE, CYCLES DOWN PRESS, CRACKED SPRINGS, MAT'L DEF.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)ORB /VEHICLE:
. (A,C) LOSS OF REDUNDANCY (ONE OF 2 FLOW PATHS). (C) ABORT DECISION.
. (D) NO EFFECT UNLESS SECOND PATH FAILS CLOSED, REENTRY CAPAB IS LOST IF FAILURE OCCURS EARLY IN ENTRY SUCH THAT ULLAGE PRESS IS NOT SUFF.
(I) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS. FAILURE OF REDUNDANT PARALLEL REG. PATH WOULD RESULT IN INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO USE RESERVED ENTRY PROPELLANT IN C.G. PROBLEMS RESULTING FROM PROPELLANT MOTION.
.CORRECTION ACTION:
. UTILIZE REDUNDANT PATH. IF BOTH PATHS ARE FAILED CLOSED EVAC REQD IF ULLAGE PRESS. INTERCONNECT WITH CMS MAY BE UTILIZED.
.REMARKS/HAZARDS:
. POSS ADVERSE EFFECT ON V.H SYS IF PROP CANNOT BE DEPLETED PRIOR TO LNDG. HELIUM MOIST CONTENT CONTROL REQ'D. SEE FAIRCHILD FMEA REPT 29-1. STAND-BY REGULATOR FLOW PATHS IS UTIL. SEE HAZ [illegible] 1Y)X-[illegible]

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201030-2 REV:11/08/7
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1
.P/N RI :MC284-0418-0001/-0002 CRIT. HDW: 2
.P/N VENDOR:74339C01 MISSIONS: HF VF X FF OF SM
.QUANTITY :8 PHASE(S): PL LO X OO X DO X LS
. :TWO PARALLEL, DUAL
. :STAGE UNITS PER TANK
. REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.OES J. TAGGART OES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: REGULATOR PRESS, HE
. SERIES REDUNDANT. SET AT UNEQUAL OUTLET PRESSURES (PP 301/302/303/304).
.FUNCTION:
. TO REGULATE STORED HELIUM PRESSURE FROM 4000 PSIG MAX TO ULLAGE PRESSURE OF 245 (+ OR - 3) PSIG FOR PURPOSE OF PROPELLANT FEED TO THRUSTERS. TWO PARALLEL PATHS WITH TWO SERIES REGS ARE PROVIDED FOR EACH PROPELLANT TANK. PRIMARY ELEMENT SET 11 PSI LOWER THAN SECONDARY.
.FAILURE MODE: FAILS CLOSED (F)
. RESTRICTED FLOW.
.CAUSE(S):
. CONTAM (PILOT SCREEN), FROZEN MOIST, SPRING/STEM FRACTURE, PISTON BINDS, EXCESS DOME PRESS, COCKED SPRINGS, MAT'L DET.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A,B) LOSS OF REDUNDANCY (ONE OF 2 FLOW PATHS). (C) ABORT DECISION. (D) NO EFFECT UNLESS SECOND PATH FAILS CLOSED, REENTRY CAPAB IS LOST IF FAILURE OCCURS EARLY IN ENTRY SUCH THAT ULLAGE PRESS IS NOT SUFF. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS. FAILURE OF REDUNDANT PARALLEL FLOW PATH WOULD RESULT IN INABILITY TO BURN OR DEPLETE RCS PROPELLANT. THIS WOULD RESULT IN POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO USE RESERVED ENTRY PROPELLANT OR C.G. PROBLEMS RESULTING FROM PROPELLANT WEIGHT.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) PARALLEL REGULATORS ARE PROVIDED. ULLAGE PRESS IS ADEQ FOR PROP FEED WITH LESS THAN 35 PERCENT PROP REMAINING. A 25-MICRON ABS GBR PLUS 10-MICRON ABS GBR PILOT FILTER IS PROV TO LIMIT THE POSSIBILITY OF CONTAM CAUSING JAMMING OF MOVING PARTS OR PLUGGING PILOT CONTROL ORIFICES. (B) 50,000 OPER FLOW CYCLES AND RANDOM VIB AT ANTIC MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM IS USED DURING SYS EVAL TESTS AT WSTF ALLOWING EVAL UNDER SIMUL MISSION USAGE COND. PROOF PRESS, LEAKAGE AND FLOW TESTING IS PERFORMED DURING ATP. FUNCT AND LEAKAGE TESTS ARE PERFORMED DURING PRE/POST FLIGHT CHECKOUT. (C) AN ID IS PERF AND THE UNIT TAGGED. MAT'L & EQUIP CONFORMANCE TO CONTRACT REQMTS IS VERIF BY INSP. THE FOLL ITEMS ARE VERIF BY SHOP TRAVELER MANDATORY INSP POINTS - RAW MAT'L, PARTS PROTECTION, MANUF, COATING, PLATING, INSTALL AND ASSY OPERATIONS. THE ABOVE ITEMS AND THE FOLL ITEMS WERE VERIF BY AUDIT CONDUCTED 4-5-77 - CONTAM CONT PROCESSES AND CORROS PROT PROV, CONTAM CONT PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIR. THE FOLLOWING

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201030-2 REV:12/08/78
ITEMS WERE VERIFIED BY AUDIT OF MARCH 6, 1978. INSPECTION VERIFIES ASSEMBLY PER INSPECTION POINTS IN MASTER RECORD. LOG OF CLEAN ROOM AND CALIBRATION OF TOOLS VERIFIED. CRITICAL DIMENSION 100% VERIFIED BY INSPECTION. PARTS CLEANLINESS AND PASSIVATION BY INSPECTION. NDE INSPECTION PERFORMED AFTER ASSEMBLY. TURNAROUND - FUNCT FLOW TESTS ARE MONITORED TO VERIFY THAT THERE IS NO RESTRICTED FLOW. (C) NO FAILURE HISTORY OF THIS MODE FOR THIS REGULATOR.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT -RCS FMEA NUMBER 03-2A-201035-1

ITEM Line, Low Pressure He FAILURE MODE External Leak

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X]	NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ]	*NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Ullage transducer will give C&W alert < 200 psi. Gross leak detection will give first indication.

3A. The helium insolation valves could be automatically closed by software upon sensing a caution and warning low pressure of 200 psi.

6. Initiate cross-feed function.

7. Caution and warning low pressure light - "Right RCS" - cathode-ray tube and down-link available.

8B. Same as primary.

(1) SYSTEM NAME - REACTION CONTROL — AREA NO. 03-24 — REVISION:
.ASSEMBLY : PRESSURIZATION — AGENT: — QTY. REQ'D:
.P/N (1) : MC 21-0004 — QTY. PER :
.P/N VENDOR : ACME CORP — MISSIONS: GP VP A TP CI
.REDUNDANCY : A — PHASE(S): PL A LL / GA A EO A ES /
: 2 OF 3 PER PROPELLANT — NUMBER OF SUCCESS PATHS REMAINING
: 4 OF 6 JETS — AFTER FIRST FAILURE:
PRELIMINARY SCREEN: A-Y/N B-Y/N C-Y/N
.CRITICALITY: 1R1 — TIME IN EFFECT:
.LIFE TEST : PRESSURE PROOF AT 1.5 NORMAL OPERATING PRESSURE — IMMEDIATE
.VENDOR-TITLE, TITLE, TITLE, & TITLE: TITLE: TITLE — BEFORE PREVIOUS EVENTS:
VS70-421001
.SPECIAL TURNAROUND?.....YES — MJ070-0001-0105
.SAME AS FLIGHT INSTRUMENTATION — SD72-SH-0103-2
MJ621-0054 (SUPERSEDES)

PREPARED BY: — APPROVED BY:
DES N. C. CLAVINICH — DES _____
REL C. M. CHERRY — REL _____

.IT IS LIKELY LOSS PRESSURE MEDIA
. FUEL LINE (L/H)
.FUNCTION:
. A/M X .0004 SQUARE INCH TO PROVIDE A MEDIUM PRESSURE FROM REGULATORS TO
FUEL TANK.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. RUPTURE, EXTERNAL LEAKAGE.
.CAUSE(S):
. MECHANICAL SHOCK, VIBRATION/FATIGUE, IMPROPER INSTALLATION (MAINT).
STRESS CORROSION, MATERIAL DEFICIENCY (SUBTIER STRUCTURE)
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF SUBSYSTEM PROPELLANT SUPPLY. INABILITY TO SUPPLY PROPELLANT. (B) LOSS OF INTERFACE FUNCTION INABILITY TO MAINTAIN ATTITUDE-PROPELLANT FOR STRUCTURAL & TPS DAMAGE. (C) POTENTIAL LOSS OF MISSION OR EARLY MISSION TERMINATION. (D) POTENTIAL LOSS OF CREW/VEHICLE IF GROSS LEAK OCCURS OR TPS DAMAGE OCCURS PRECLUDING SAFE ENTRY.
.CORRECTIVE ACTION:
. INSTALL REDUNDANT FUEL LINE (EARLY DETECTION OF LEAK SIZE). LINE SHALL BE SO ROUTED AS NEEDED. UTILIZE ULLAGE IF FAIL DOWNSTREAM OF CHECK VALVES.
.REMARKS/HAZARDS:
. VEHICLE DYNAMICS MAY BE ADVERSELY AFFECTED BY SIGNIFICANT AMOUNT OF PROPELLANT LOSS. LOW OVERPRESSURE MAY RESULT IN DAMAGE TO STRUCTURE & TPS.
REF HAZ NO. 1YA/-0003-02.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201035-1 REV:11/08/78
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1
.P/N RI :MC621-0059 CRIT. HDW: 1
.P/N VENDOR:73A630030 MISSIONS: HF VF X FF OF SM
.QUANTITY :4 PHASE(S): PL X LO X CO X DO X LS X
. :ONE SET PER PROPELLANT
. :PER MODULE
. REDUNDANCY SCREEN: A-N/A B-N/A C-N/A
.

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES N C GLAVINICH DES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: LINE, LOW PRESSURE HE.
. FEED LINE (3/4")
.FUNCTION:
. 3/4 X .020 304L S.S LINES TO PROVIDE HELIUM FEED FROM REGULATORS TO PROP TANK.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. RUPTURE, EXTERNAL LEAKAGE.
.CAUSE(S):
. MECHANICAL SHOCK, VIBRATION/FATIGUE, IMPROPER INSTALLATION (WELD). STRESS CORROS, MAT'L DEFICIENCY (SULPHIDE STRINGER)
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF SUBSYSTEM HELIUM SUPPLY. INABILITY TO DEPLETE/UTILIZE PROPELLANT. (B) LOSS OF INTERFACE FUNCTION INABILITY TO REPRESSURE PROP TANK-POTENT POD STRUCTURE & TPS DAMAGE. (C) POTENTIAL LOSS OF MISSION OR EARLY MISSION TERMINATION. (D) POTENTIAL LOSS OF CREW/VEHICLE IF GROSS LEAK OCCURS OR TPS DAMAGE OCCURS PRECLUDING SAFE ENTRY.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 1.5 TO 4.0 MAXIMUM OPERATING PRESSURE (SYSTEM RELIEF). THE WELDED CONSTRUCTION ELIMINATES JOINTS AND POSSIBLE LEAK PATHS. THE ANNEALED AREA (DUE TO WELDING) IS BACKED UP BY A SLEEVE. FASTENING CLAMPS ALLOW FREEDOM OF MOVEMENT. TUBING BENDS ARE CONTROLLED BETWEEN FIXED POINTS TO FACILITATE INSTALLATION AND ACCOMMODATE VEHICLE GROWTH AND MOVEMENT. (B) ROCKWELL PERFORMED TUBING CERTIFICATION TESTS PER "ORBITER TUBING VERIFICATION PLAN" (SD75-SH-0205). THIS TESTING INCLUDED PRESSURE CYCLING AND FATIGUE FOR TYPICAL SHUTTLE LINES & JOINTS. SYSTEM EVALUATION TESTS AT WSTF WILL ALSO ALLOW EVALUATION IN THE INSTALLED SYSTEM CONDITION. LEAKAGE TESTS ARE PERFORMED IN-PROCESS FOR TUBING SECTIONS. OPTICAL INSPECTIONS ARE ALSO PERFORMED AT THIS TIME IN ADDITION TO X-RAY AND DYE PENETRANT. LEAKAGE TESTS ARE ALSO PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND ADDITIONAL WELDS ARE ALSO SUBJECTED TO NDE. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAM. CONTROL PROCESSES, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS AND INSP. FOR SURFACE AND SUB-SURFACE DEFECTS IS VERIFIED BY INSPECTION. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP. POINTS, RAW MAT'L (LOT CERTIFICATION), PARTS PROTECTION, MANUF., COATING, PLATING, INSTALLATION AND ASSEMBLY OPERATIONS. HARDWARE IS INSP. IN ACCORDANCE WITH QUALITY

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201035-1 REV:11/03/75
PLANNING REQMITS DOCUMENT (CPRO) WHICH HAS BEEN APPROVED BY NASA.
TURNAROUND. LINES IN ACCESSIBLE AREAS ARE VISUALLY INSPECTED FOR
EVIDENCE OF DAMAGE AND FLOW AND PRESSURE FUNCTIONAL TESTS ARE MONITORED
FOR EVIDENCE OF OBSTRUCTION OR LEAKAGE. (D) MINOR HISTORY -
CORROSION/FAB PROBLEMS DETECTED DURING APOLLO CHECKOUT AND CORRECTED.
HISTORY - CORROSION/FAB PROBLEMS DETECTED DURING APPOLLO CHECKOUT AND
CORRECTED.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201060-4

ITEM Relief Valve FAILURE MODE External Leak -- Fails Open

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection will give first indication.

1a. Measurements V42P2115, 2116, 3115, and 3116 provide propellant tank ullage pressure signals from transducers.

6. Left and right AFT RCS pods provide redundancy.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

2

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201060-# REV:12/14/7?
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1R
.P/N RI :MC284-0421-0001/-0002 CRIT. HDW: 2
.P/N VENDOR:5760009-101/576-0009-102 MISSIONS: HF VF X FF OF SM
.QUANTITY :4 PHASE(S): PL LO X CO X OO X LS
. :ONE PER PROPELLANT TANK
.

REDUNDANCY SCREEN: A-PASS B-FAIL C-PASS

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES R. GONZALEZ R.G. DES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: VALVE
. RELIEF, PRESSURE, BURST DISC & POPPET.

.FUNCTION:
. PROVIDES PRESSURE RELIEF IN EVENT REGULATOR FAILS OPEN OR PROPELLANT PRESSURE RISES DUE TO THERMAL INCREASE. THE S.S. BURST DISC RELIEF PRESSURE IS 324-340 PSIG. THE MAIN POPPET CRACK AND RELIEF PRESSURE IS 315 PSIG AND THE MINIMUM RESEAT PRESSURE IS 310 PSI. AMBIENT PRESSURE SENSING INTERNAL IS PROVIDED SINCE THE VALVE OUTLET IS SUBJECTED TO BACK-PRESSURE.

.FAILURE MODE: EXTERNAL LEAK (F)
. FAILS OPEN, MAIN POPPET OR DIAPHRAGM LEAKS OR MAIN POPPET DOES NOT RESEAT AS REQ'D AFTER BURST DISC RUPTURE.

.CAUSE(S):
. CORROSION, CONTAMINATION, POPPET BINDS IN GUIDE, SPRING BREAKS OR COCKS, SEAT CRACKS, MOISTURE FREEZES, VIBRATION, SHOCK.

.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF SUBSYTEM PRESSURIZATION. (B) LOSS OF INTERFACE FUNCTION (INABILITY TO RE-PRESSURIZE PROPELLANT TANKS DUE TO HELIUM LOSS). POSSIBLE INABILITY TO USE/DEPLETE PROPELLANT. (C) LOSS OF ENTRY CAPABILITY - ASSUMES ULLAGE PRESSURE IS ALSO VENTED OVERBOARD & PROP CANNOT BE DEPLETED. (2 FAILURES - FIRST IS RELIEF REQ'MT). ABORT DECISION IF LEAK RATE IS SMALL. (D) NO EFFECT (FIRST FAILURE. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE LOSS OF CREW VEHICLE - SEE ITEM (C) ABOVE. PROP IN ONE POD MAY NOT BE ADEQUATE FOR ENTRY. POSS ENTRY CONTROL & LANDING HAZARD (C.G.) IF PROP CANNOT BE DEPLETED PRIOR TO LANDING.

.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) THE BURST DISC IS REDUNDANT TO THE MAIN POPPET FOR THE EXTERNAL LEAKAGE MODE. (MAIN POPPET LEAKAGE WOULD NOT BE SENSED UNTIL AFTER BURST DISC ACTUATION OR FAILURE). A 25-MICRON FILTER DOWNSTREAM OF THE BURST DISC WILL REDUCE THE POTENTIAL FOR CONTAMINATION CAUSED LEAKAGE FAILURE. THE HELIUM ISOLATION VALVE COULD BE CLOSED DURING STATIC PERIODS. THIS WOULD PREVENT CONTINUING LOSS OF SOURCE PRESSURE. THE MAIN POPPET STEM IS A SEPARATE PIECE FROM THE MAIN SENSING SPRING ACTUATION MECHANISM. THIS PROVIDES CLOSE TOLERANCE CONTROL OF OPENING PRESSURE & ALLOWS THE POPPET TO SEAT INDEPENDENTLY OF THE LARGE SENSOR SPRING FORCE. (B) 36,000 PRESSURE EXCURSION CYCLES AT SYSTEM OPERATING

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201060-4 REV:12/14/73

PRESSURE AND 400 PRESSURE RELIEF CYCLES ARE CONDUCTED DURING QUAL. (C) AN IDENTIFICATION IS PERFORMED CONTAMINATION CONTROL PROCESS, CONTAMINATION CONTROL PLAN, CORROS, PROTECTION PROVISION, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, AND MAT'L AND EQUIP, CONFORMANCE TO CONTRACT REQMTS. ARE VERIFIED BY INSP. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS-RAW MAT'', (LOT CERTIFICATION), PARTS PROTECTION, MANUF., COATING, PLATING, INSTALLATION AND ASSY OPERATIONS. TURNAROUND - LEAKAGE TESTS ARE MONITORED TO VERIF. THAT THE BURST DISC IS STILL INTACT AND THAT THE MAIN POPPET LEAK RATE IS WITHIN SPECIFICATION REQMTS. VISUAL INSP FOR EVIDENCE OF DETERICRATION IS ALSO PERFORMED. (D) APOLLO FAILURES WERE DO LARGELY TO GALVANIC CORROS. & CONTAMINATION CORRECTED BY DESIGN & TEST PROCESSING CHANGES. (THE SHUTTLE RELIEF VALVE IS A NEW DESIGN WHICH CONTAINS A FILTER & DOES NOT USE DISSIMILAR METALS).

SPACE SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - CRITICAL ITEMS

SUBSYSTEM: MPS - PROPELLANT CONTROL
REF DES: V26-2115,2116
QUANTITY: 2
PER PROPELLANT TANK
FMEA NO: 03-28
REV: 12/15/77
CRIT. FC: 2
CRIT. FF: 1
MISSION: ALL
PHASE(S): PL
NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE: 1
REDUNDANCY SCREEN: A-PASS B-FAIL C-N/A
FAILURE ELIMINATED IN FLIGHT: YES
HELIUM PRESS MEAS: V42P-2115,2116
TANK ULLAGE PRESS
CRITICAL ITEMS: YES
MPS-PCN TLM
TIME TO EFFECT: IMMEDIATE TO 3 HRS
REFERENCE DOCUMENTS.
MC 611-0039
MJ570-0001-0105
SS72-SP-0100-2
VS70-431-01

PREPARED BY: L. E. S. N. GONZALEZ
REL C. M. AKERS

APPROVED BY:
ICS _____
REL _____

ITEM: VALVE
- RELIEF, PRESSURE, BURST DISC & POPPET, MV 201/202/203/204. 315 PSIA. MV 301/302/303/304.

FUNCTION:
- PROVIDES PRESSURE RELIEF IN EVENT REGULATOR FAILS OPEN TO PROPELLANT PRESSURE (PRESS REG TO THERMAL INCREASE. THE SYS. BURST DISC RELIEF PRESSURE IS 345-340 PSIG. THE MAIN POPPET CRACK AND RELIEF PRESSURE IS 315 PSIG AND THE MINIMUM RESEAT PRESSURE IS 310 PSI. A LEAK PRESSURE SENSING INTERNAL IS PROVIDED SINCE THE VALVE OUTLET IS SUBJECTED TO BACK-PRESSURE.

FAILURE MODE: EXTERNAL LEAK (F)
- FAILS OPEN, MAIN POPPET OR DIAPHRAGM LEAKS OR MAIN POPPET DOES NOT RESEAT AS CLOSED AFTER BURST DISC RUPTURE.

CAUSE(S):
- CORROSION, CONTAMINATION, POPPET BINDS IN GUIDE, SPRING BREAKS OR COCKS, SEAT CRACKS, MOISTURE FREEZES, VIBRATION, SHOCK.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF SUBSYSTEM PRESSURIZATION. (B) LOSS OF INTERNAL PROPELLANT (INABILITY TO PRESSURIZE PROPELLANT TANKS DUE TO FLIGHT CRITICAL). POSSIBLE INABILITY TO USE/DEPLETE PROPELLANT. (C) LOSS OF ENTRY CAPABILITY - ASSUMES ULLAGE PRESSURE IS ALSO VENTED OVERBOARD & PROP CANNOT BE DEPLETED. (2 FAILURES - FIRST IS RELIEF POINT). APEN DECISION IF LEAK RATE IS SMALL. (D) NO EFFECT (FIRST FAILURE). (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE LOSS OF CREW/VEHICLE - SEE ITEM (C) ABOVE. PROP IN ONE POD MAY NOT BE ADEQUATE FOR ENTRY. POSS ENTRY CONTROL & LANDING HAZARD (C.G.) IF PROP CANNOT BE DEPLETED PRIOR TO LANDING.

CORRECTIVE ACTION:
- ABORT RTLS, RESCUE (AYBY) RTLS IF ONE POD'S PROP CANNOT BE DEPLETED OR IS NOT ADEQUATE FOR ENTRY. DEPLETE DISABLE POD PROP FIRST THEN MANUAL

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201070-1

ITEM He Fill Quick Disconnect FAILURE MODE Fails Open

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In-Flight detectability
[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection will give first indication.

6. Capped quick disconnect provides one redundant success path.

Pod Redundancy

[illegible] SYSTEM : -T - PROPELLANT CONTROL
[illegible] BY : [illegible]
[illegible] NO : 0170-0017-0401/-0403
[illegible] VOLUME : [illegible]
[illegible] ITEM : [illegible]
[illegible] [illegible] PRESS REGULATOR TANK P/P
[illegible]

PAGE NO 08-2A -[illegible]
DATE: [illegible]
MISSIONS: [illegible]
PHASE(S): PL [illegible]
NUMBER OF SUCCESS PATHS REMAINING
AFTER FIRST FAILURE: 1
CRITICALITY CODE : A-/A 1-A/A 2-/A

FAIL SAFE OUT CAPABLE IN FLIGHT? NO

MISSION TURNAROUND.....YES
VISUAL INSPECTION PRIOR TO LAUNCH
ITEM

FAIL IF REPEAT:
SECONDS TO DAYS
REFERENCE DOCUMENTS:
MC 521-0009
MJC70-0011-[illegible]
SD72-SH-[illegible]
V570-40101

PREPARED BY: C SCARLETT
DES
REL C [illegible] AKERS

APPROVED BY:
DES _____
REL _____

ITEM: DISCONNECT,QUICK,FILL,LE
(1/4") WITH SPRING LOADED POPPET AND STRUCTURAL LOCK CAP. MS [illegible]
FUNCTION:
- PROVIDE HELIUM TANK FILL AND VENT POINT FOR GROUND SERVICE & CHECKOUT AND LOADING. COUPLING IS ACCESSIBLE AT THE HELIUM SERVICING PANEL.
FAILURE MODE: FAILS [illegible] (S)
- EXCESS OF ACCEPTABLE RATE, SEALS DAMAGED.
CAUSE(S):
- CONTAMINATION, VIBRATION, MECHANICAL SHOCK, PIECE-PART STRUCTURAL FAILURE, EXCESS OR IMPROPER USE, INADEQ MAINT OR USE WEAR, NO LOCK SPRING - SHAFT OR BODY CONT. REMAINING CAP LOOSENS MECHANG CAP SEAL REDUNDANCY.
EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
- (A) LOSS OF SUB-SYSTEM PRESSURIZATION (B) LOSS OF INTERFACE FUNCTION. (INABILITY TO REPRESSURIZE PROPELLANT TANKS DUE TO HELIUM LOSS). (C) LAUNCH DELAY OR ABORT. (D) POTENTIAL CREW LOSS DURING MISSION IF PROPELLANT CANNOT BE UTILIZED OR DEPLETED.
CORRECTIVE ACTION:
- [illegible] CAPABILITY FOR ABORT. UTILIZE PROPELLANT FROM [illegible] FIRST IF PRESSURE CAN BE MAINTAINED.
REMARKS/HAZARDS:
- BECAUSE A STRUCTURAL CAP IS SPRING LOADED OVER THE DISCONNECT, THIS FAILURE MODE IS VERY REMOTE (IN FLIGHT). POSSIBLE ADVERSE EFFECT ON VEHICLE DYNAMICS IF PROP CANNOT BE DEPLETED PRIOR TO LANDING. USE LINES MUST BE SUPPORTED. REF HAZ NO 1YXX-0002-04.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -231070-1 REV:12/12/78
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1
.P/N RI :MC276-0017-0402/-0403 CRIT. HDW: 1
.P/N VENDOR:7537200C-0401/-0403 MISSIONS: HF VF X FF OF SM
.QUANTITY :4 PHASE(S): PL X LO X OO X DO X LS X
. :ONE PER HELIUM TANK PER
. :POD
. REDUNDANCY SCREEN: A-N/A B-N/A C-N/A
.
.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES C SCARLETT DES C. Scarlett 12/5/78 SSM W. Kaschuk
.REL C M AKERS REL C E Daniel 1-2-79 REL Earl Daniel
. APPROVED WITH CHANGES
See Section 13.0
.ITEM: DISCONNECT,QUICK,FILL,HE
. (1/4") WITH SPRING LOADED POPPET AND STRUCTURAL END CAP. MD 219/220
.FUNCTION:
. PROVIDE HELIUM TANK FILL AND VENT POINT FOR GROUND SERVICING OPERATIONS AND LOADING. COUPLING IS ACCESSIBLE AT THE HELIUM SERVICING PANEL.
.FAILURE MODE: FAILS OPEN (S)
. EXCESS OF ACCEPTABLE RATE, SEALS DAMAGED.
.CAUSE(S):
. CONTAMINATION, VIBRATION, MECHANICAL SHOCK, PIECE-PART STRUCTURAL FAILURE, EXCESS OR IMPROPER USE, INADEQ MAINT OR GSE MALF, NO LINE SUPPORT - SHAFT OR BORE BENT. RETAINING CAP LOOSENS NEGATING CAP SEAL REDUNDANCY.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF SUB-SYSTEM PRESSURIZATION (B) LOSS OF INTERFACE FUNCTION (INABILITY TO REPRESSURIZE PROPELLANT TANKS DUE TO HELIUM LOSS). (C) LAUNCH DELAY OR ABORT. (D) POTENTIAL CREW LOSS DURING MISION IF PROPELLANT CANNOT BE UTILIZED OR DEPLETED.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 2.0 X WORKING PRESS. ULLAGE PRESS IS ADEQ TO EXPEL PROP WITH 35 PERCENT OR LESS REMAINING. GROUND HALF COUPLINGS AND LINES ARE SUPPORTED TO LIMIT ANY UNDUE STRESS ON THE COUPLING DURING SERVICE AND PREV DAMAGE TO SEALS. A SAFETY FEATURE DURING SERVICING AND PRIOR TO REMOVAL OF THE END CAP IS A PROV WHEREBY ANY LEAKAGE PAST THE AIRBORNE POPPET SEAL CAN BE VENTED OVERBOARD BY ROTATING A BLEED SCREW. COMPLETE STRESS ANAL HAS BEEN CONDUCTED. UTIL OF STRUCT CAP MINIMIZES LEAKAGE POTENTIAL AND PROVIDES A REDUN SEAL EXCEPT FOR STRUCT FAILURE. (B) THE COUPLING IS SUB TO 600 OPERATIONAL CYCLES (COUPLING AND UNCOUPLING) DURING QUAL. RANDOM VIB TESTING IS ALSO CONDUCTED AT ANTIC VEH LEVELS FOR 48 MINUTES IN TWO AXES. USAGE DURING SYS EVAL TESTS AT WSTF ALLOWS EVAL UNDER ACTUAL USAGE CON. PROOF PRESS TESTS ARE CONDUCTED DURING ATP AND LEAKAGE TESTS ARE PERF BEFORE AND AFTER OPER CYCLES. (C) AN IDENT IS PERF. RAW MAT'L, NDE EXAM, VISUAL INSP FOR CRITICAL SURFACE DEFECTS, AND EQUIP CONFORMANCE TO CONTRACT REQMTS ARE VERIF BY RECEIVING INSP. MEASUREMENT STANDARDS AND TEST EQUIP. STANDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPEC. THE FOLLOWING ITEMS ARE VERIF BY SHOP TRAVELER MANDATORY INSP POINTS. PARTS MFG. PROCESSES, COATING, ASSY AND INSTALLATION. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 5-23-77. CORROS PROT PROV, CONTAM CONT PROCESSES, TEST

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201070-1 REV:12/12/78
HANDLING, AND STORAGE ENVIR. THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT OF MARCH 6, 1978. INSPECTION VERIFIES ASSEMBLY PER INSPECTION POINTS IN MASTER RECORD. LOG OF CLEAN ROOM AND CALIBRATION OF TOOLS VERIFIED. CRITICAL DIMENSION 100% VERIFIED BY INSPECTION. PARTS CLEANLINESS AND PASSIVATION VERIFIED BY INSPECTION. NDE INSPECTION PERFORMED AFTER ASSEMBLY. TURNAROUND. COUPLINGS ARE VISUALLY INSP FOR EVID OF DAMAGED SEALS AND LEAK TESTS ARE PERFORMED. (C) APOLLO FAILURE HISTORY WAS IN THE MAIN ASSOC WITH GROUND USAGE, IMPROPER HANDLING.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201080-1

ITEM Purge Quick Disconnect, Propellant FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ]	*NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X]	*1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection will give first indication.

2. The above statement indicates in-flight detection.

6. Need minimum of 2 yaw thrusters. Cross-feed is available. Pods are redundant.

.SUBSYSTEM: REACTION CONTROL FMEA NO (SEE -POINT-): REVISION:
.ITEM: IDENTIFICATION: CRIT: CRIT. NO (S):
.FUNCTION: CRIT. FAIL:
.REDUNDANCY: MISSION PHASES: OPS VP A PL DP SO
.CRITICALITY: PHASES(S): PL LO X SO A VE X ES
. NUMBER OF SUCCESS PATH REMAINING
. ORBIT FIRST FAILURE:
. EMERGENCY SCRUB: A-PASS I-FAIL O-
. TIME TO EFFECT:
. SPARES IN BAY:
. REFERENCE DRAWINGS:
. RC 0271-0039
. MJ073-0001-0018
. S072-SR-0103-A
. V570-4211-01

. MISSION CRITICAL IN FLIGHT? NO
.
.
.
. ANY LOC TURNAROUNDS.....YES
. VISUAL INSPECTION
.
.
.
. PREPARED BY: APPROVED BY:
. DES C SCARLETT DES _____
. REL C MAKERS REL _____
.
.
.ITEM: DISCONNECT, QUICK, PURGE,
. VENT, PROPELLANT WITH STRUCTURAL END CAP AND SPRING LOADED POPPET (2/_M).
.FUNCTION:
. TO ALLOW GN2 PURGE OF PROPELLANT MANIFOLDS DURING TURNAROUND OPERATIONS.
.FAILURE MODE: EXTERNAL LEAKAGE (S)
. CAP LEAKS, SEALS DAMAGED RETAINING NUT LOOSENS NEGATIVE CAP SEAL PRESSURE.
.CAUSE(S):
. VIBRATION, PIECE PART STRUCTURAL FAILURE, CONTAMINATION, MECHANICAL SHOCK, SEAL DAMAGE, INADEQUATE MAINT OF GSE MATE, NO LINE SUPPORT - CRAFT OR GSE INTERFACE
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A,B) LOSS OF REDUNDANCY (ONE COUPLING FOR EACH OF 2 MANIFOLDS - PROPELLANT MANIFOLD ISOLATION VALVE COULD ISOLATE LEAK). (C) MISSION MODIFICATION OR ABORT DECISION. (D) NO EFFECT UNLESS MULTIPLE FAILURES OCCUR OR EXCESS LOSS OF PROPELLANT OCCURS. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE DELAY/VEHICLE LOSS - LOSS OF MPS DELAY FROM LEAK. POSSIBLE LOSS OF VEHICLE CONTROL DURING ENTRY.
.CORRECTING ACTION:
. DETERMINE LEAK LOCATION. CLOSE PROPELLANT MANIFOLD ISOLATION VALVE. EVALUATE NEED TO ABORT.
.REMARKS/HAZARDS:
. POTENTIAL EXPOSION TO SURROUNDING AREA. CAP CONSIDERED AS STRUCTURE. POTENTIAL TOXIC & FIRE, OR EXPLOSIVE HAZARD IF HIGH TEMPERATURE OR REACTANTS ARE PRESENT. REF HAZ NO 1YXX-0502-04.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201080-1 REV:11/08/7
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1R
.P/N RI :MC276-0018 CRIT. HDW: 2
.P/N VENDOR:76361000 & 76316000 MISSIONS: NF VF X FF OF SM
.QUANTITY :28 PHASE(S): PL LO X CO X DO X LS
. :
. :14 PER POD
. 12 OF 1/2 IN.
. 2 OF 1/4 IN. REDUNDANCY SCREEN: A-PASS B-FAIL C-PASS
.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES C SCARLETT DES C. Scarlett 12/15/78 SSM W. Kontilla
.REL C M AKERS REL C.E. Daniel 12/7/78 REL J.A. Faudsmith
.
APPROVED WITH CHANGES
See Section 13.0

.ITEM: DISCONNECT,QUICK, PURGE,
. VENT, PROPELLANT WITH STRUCTURAL END CAP AND SPRING LOADED POPPET (1/2" & 1/4 IN.).
.FUNCTION:
. TO ALLOW GROUND PURGE OF PROPELLANT MANIFOLDS DURING TURNAROUND OPERATIONS.
.FAILURE MODE: EXTERNAL LEAKAGE (S)
. CAP LEAKS, SEALS DAMAGED RETAINING NUT LOOSENS NEGATING CAP SEAL REDUNDANCY.
.CAUSE(S):
. VIBRATION, PIECE PART STRUCTURAL FAILURE, CONTAMINATION, MECHANICAL SHOCK. SEAL DAMAGE, INADEQ MAINT OF GSE HALF, NO LINE SUPPORT - SHAFT OR BORE BENT
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A,B) LOSS OF REDUNDANCY (PROPELLANT MANIFOLD ISOLATION VALVE COULD ISOLATE LEAK). (C) MISSION MODIFICATION OR ABORT DECISION. (D) NO EFFECT UNLESS MULTIPLE FAILURES OCCUR OR EXCESS LOSS OF PROPELLANT OCCURS. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS - LOSS OF RCS ENTRY PROPELLANT. POSSIBLE LOSS OF VEHICLE CONTROL DURING ENTRY.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 2.0 X WORKING PRESS. REDUNDANCY PROVIDED BY INTERNAL SEAL, CAP & MANIFOLD ISOLATION VALVE. GROUND HALF COUPLINGS AND LINES ARE ADEQ SUPPORTED TO LIMIT ANY UNDUE STRESS ON THE COUPLING DURING SERVICE AND PREV DAMAGE TO SEALS. A SAFETY FEATURE DURING SERVICING AND PRIOR TO REMOVAL OF THE END CAP IS A PROV WHEREBY ANY LEAKAGE PAST THE AIRBORNE POPPET SEAL CAN BE VENTED OVERBOARD BY ROTATING A BLEED SCREW. COMPLETE STRESS ANAL HAS BEEN CONDUCTED. UTIL OF STRUCT CAP MINIMIZES LEAKAGE POTENTIAL AND PROVIDES A REDUM SEAL EXCEPT FOR STRUCT FAILURE. FAILURE CAN BE ISOLATED AT MANIFOLD VALVE. (B) THE COUPLING IS SUBJ TO 600 OPER CYCLES (COUPLING AND UNCOUPLING) DURING QUAL IN ADDITION TO PRESS SURGE CYCLING AND PROP EXPOSURE TESTS. RANDOM VIB TESTING IS ALSO CONDUCTED AT ANTIC VEH LEVELS FOR 34 MINUTES IN EACH AXIS. USAGE DURING SYS EVAL TESTS AT WSTF ALLOWS EVAL UNDER ACTUAL USAGE COND. PROOF PRESS TESTS ARE CONDUCTED DURING ATP AND LEAKAGE TESTS ARE PERF BEFORE AND AFTER OPER CYCLES. (C) AN IDENT IS PERF. RAW MAT'L, NDE EXAM. VISUAL INSP FOR CRITICAL SURFACE DEFECTS, AND EQUIP CONFORMANCE TO CONTRACT REQMTS ARE VERIF BY RECEIVING INSP. MEASUREMENT STANDARDS AND

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201080-1 REV:11/08/78
TEST EQUIP. STNDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPECS. THE FOLLOWING ITEMS ARE VERIF BY SHOP TRAVELER MANDATORY INSP POINTS-PARTS PROT, MFG. PROCESSES, COATING, ASSY AND INSTALLATION. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 5-23-77. CORROS PROT, PROV CONTAM CONT PROCESSES, TEST HANDLING, AND STORAGE ENVIR. THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT OF MARCH 6, 1978. INSPECTION VERIFIES ASSEMBLY PER INSPECTION POINTS IN MASTER RECORD. LOG OF CLEAN ROOM AND CALIBRATION OF TOOLS VERIFIED. CRITICAL DIMENSION 100% VERIFIED BY INSPECTION. PARTS CLEANLINESS AND PASSIVATION VERIFIED BY INSPECTION. NDE INSPECTION PERFORMED AFTER ASSEMBLY. TURNARCUND-COUPLINGS WILL BE VISUALLY INSPECTED FOR EVIDENCE OF CAP SEAL DAMAGE AND CAP LEAKAGE. (D) APOLLO FAILURE HISTORY WAS IN THE MAIN ASSOC WITH GROUND USAGE, IMPROPER HANDLING.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201090-1

ITEM Test Quick Disconnect FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ]	*NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES	3. [ ] NO SOFTWARE DETECTION	5. [ ] ACCEPTANCE RATIONALE BELOW
2. [X] HARDWARE ACCEPTS RISK	4. [ ] DETECTION DURING CHECKOUT	6. [ ] RECOMMENDED CHANGES BELOW

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection gives first indication.

2. FMEA change - in flight detectability should include above measurement numbers.

6. Pod redundancy.

SYSTEM FAILURE MODE AND EFFECTS ANALYSIS - UNFILLED [illegible]

SUBSYSTEM: RCS - REACTION CONTROL
ASSEMBLY: RCS PROPELLANT
P/N: [illegible]
NOMENCLATURE: [illegible]
QUANTITY: ONE
PER MODULE

FMEA NO: CS-RCS-[illegible]-1
ALERT:
MISSIONS: ME ME A PE LE LA
PHASE(S): PL LO X ... P ... S
NUMBER OF SUCCESS PATH: REMAINING
AFTER FIRST FAILURE:
REDUNDANCY SCREEN: A-PASS B-FAIL C-[illegible]
TIME TO EFFECT:
SECONDS TO DAYS
REFERENCE DOCUMENTS:
VS70-[illegible]
MC631-[illegible]
MJ070-[illegible]
SD72-SH-[illegible]

FAILURE IS DETECTABLE IN FLIGHT: YES
FLIGHT CREW PROCEDURE: V42F-[illegible]
[illegible] 21140
TURNAROUND?.....N/A

PREPARED BY: C SCARLETT DES, C MARKERS REL
APPROVED BY: DES _____ REL _____

ITEM: DISCONNECT, QUICK, TEST
PL (1/4") WITH SPRING LOADED POPPET AND STRUCTURAL LOCK CAP. NO [illegible] 64/207-116/801-804/207-816

FUNCTION:
TO PROVIDE ACCESS TO THE HELIUM SUPPLY SYSTEM AT VARIOUS POINTS IN THE SYSTEM (RELIEF VALVES/ TEST LINES REGULATORS, CHECK VALVES). PROVIDES FOR C/O OF PRESS SUB-SYS COMPONENTS. COMPONENT INPUTS & OUTPUTS ARE ACCESSIBLE AT RE SERV PANEL. THE END CAP PROVIDES REDUNDANCY FOR EXTERNAL LEAK.

FAILURE MODE: EXTERNAL LEAKAGE (S)
CAP LEAKS, SEALS DAMAGED.

CAUSE(S):
VIBRATION, MISC PART STRUCTURAL FAILURE (POPPET, SEAL), MECHANICAL SHOCK. EXCESS TORQUE, SEAL DAMAGE, INADEQ MAINT OF GSE MATE, INC LINE SUPPORT - SPART OR LONG TERM.

EFFECTS): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF SUBSYSTEM PRESSURIZATION OR REDUNDANCY DEPENDING ON LOCATION. (B) LOSS OF INTERFACE FUNCTION (LOSS OF PROPELLANT FEED CAPABILITY). (C,D) NO EFFECT DUE TO REDUNDANT POPPET [illegible] END CAP. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS. LOSS OF PRESSURANT RESULTS IF INABILITY TO BURN OR DEPLETE RCS PROPELLANT. THIS WOULD RESULT IN POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO USE RESERVE ENTRY PROPELLANT OR C.G. PROBLEMS RESULTING FROM PROPELLANT WEIGHT.

CORRECTIVE ACTION:
ISOLATE LEAK IF POSSIBLE. CONSIDER USAGE OF ULLAGE PRESSURIZATION AND NECESSITY FOR ALERT. CLOSE ISOLATION VALVE DURING STATIC REGIMES.

REMARKS/HAZARDS:
FAILURE MOST PROBABLE DURING GROUND USAGE. GSE LINES MUST BE SUPPORTED. POSSIBLE ADVERSE EFFECT ON VEHICLE DYNAMICS IF PROP CANNOT

[illegible] SUBSYSTEM: [illegible] - REACTION CONTROL FMEA NO G-2A -[illegible]-1 [illegible]
[illegible] PAGE NO [illegible]

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201090-1 REV:12/12/7o
.ASSEMBLY :PRESSURIZATION ABORT: CRIT. FUNC: 1R
.P/N RI :ME27o-0032-0005,7,19,21 CRIT. HDW: 3
.P/N VENDOR:RR42670-5,-7RG4290J-1&-3 MISSIONS: HF VF X FF OF SM
.QUANTITY :36 PHASE(S): PL LO X OO X OG X LS
. :18 PER MODULE
.

REDUNDANCY SCREEN: A-FAIL B-FAIL C-PASS

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES C SCARLETT DES C. Scarlett 12/15/78 SSM W. Kanabrocki
.REL C M AKERS REL C.E. Daniel 12/7/7 REL [illegible]

APPROVED WITH CHANGES
See Section 13.0

.ITEM: DISCONNECT, QUICK, TEST
. PT. (1/4") WITH SPRING LOADED POPPET AND STRUCTURAL END CAP. MO 201-204/207-216/301-304/307-316
.FUNCTION:
. TO PROVIDE ACCESS TO THE HELIUM SUPPLY SYSTEM AT VARIOUS POINTS IN THE SYSTEM (RELIEF VALVES/BURST DISCS REGULATORS, CHECK VALVES). PROVIDES FOR C/O OF PRESS SUB-SYS COMPONENTS. COMPONENT INPUTS & OUTPUTS ARE ACCESIBLE AT HE SERV PANEL. THE END CAP PROVIDES REDUNDANCY FOR EXTERNAL LEAK.
.FAILURE MODE: EXTERNAL LEAKAGE (S)
. CAP LEAKS, SEALS DAMAGED.
.CAUSE(S):
. VIBRATION, PIECE PART STRUCTURAL FAILURE (POPPET, SEAL), MECHANICAL SHOCK. EXCESS TORQUE, SEAL DAMAGE, INADEQ MAINT OF GSE HALF, NO LINE SUPPORT - SHAFT OR BORE BENT.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF SUBSYSTEM PRESSURIZATION OR REDUNDANCY DEPENDING ON LOCATION . (B) LOSS OF INTERFACE FUNCTION (LOSS OF PROPELLANT FEED CAPABILITY). (C,D) NO EFFECT DUE TO REDUNDANT POPPET SEALS & END CAP. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS. LOSS OF PRESSURANT RESULTS IN INABILITY TO BURN OR DEPLETE RCS PROPELLANT. THIS WOULD RESULT IN POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO USE RESERVED ENTRY PROPELLANT OR C.G. PROBLEMS RESULTING FROM PROPELLANT WEIGHT.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 2.0 X WORKING PRESS. ULLAGE PRESS IS ADEQ TO EXPEL PROP WITH 35 PERCENT OR LESS REMAINING. GROUN HALF COUPLINGS AND LINES ARE ADEQ SUPPORTED TO LIMIT ANY UNDUE STRESS ON THE COUPLING DURING SERVICE AND PREV DEMAGE TO SEALS AND WELD JOINTS. A SAFETY FEATURE DURING SERVICING AND PRIOR TO REMOVAL OF THE END CAP IS A PROV WHEREBY ANY LEAKAGE PAST THE AIRBORNE POPPET SEAL CAN BE VENTED OVERBOARD BY ROTATING CAP. UTIL OF STRUCT CAP MINIMIZES LEAKAGE POTENTIAL AND PROVIDES A REDUN SEAL EXCEPT FOR STRUCT OR WELD FAILURES. (B) THE COUPLING IS DESIGNED FOR 400 OPER CYCLES (COUPLING AND UNCOUPLING). USAGE DURING SYS EVAL TESTS AT WSTF ALLOWS EVAL UNDER ACTUAL USAGE COND. PROOF PRESS TESTS ARE CONDUCTED DURING ATP AND LEAKAGE TESTS ARE PERF BEFORE AND AFTER OPER CYCLES. (C) AN IDENT IS PERF AND THE UNIT TAGGED. RAW MAT'L, NDE EXAM OF WELDS, VISUAL INSP. OF WELD JOINTS FOR

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201090-1 REV:12/12/78

CONFORMANCE TO STANDARD WELD PRACTICE, SURFACE DEFECTS, AND EQUIP CONFORMANCE TO CONTRACT REQMTS ARE VERIF BY RECEIVING INSP. MEASUREMENT STANDARDS AND TEST EQUIP. STANDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPECS. THE FOLLOWING ITEMS ARE VERIF BY SHOP TRAVELER MANDATORY INSP POINTS- PARTS PROT, MFG. PROCESSES, COATING, PLATING, ASSY AND INSTALLATION. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 11-3-76. CORROS PROT PROV, CONTAM CONT PROCESSES, TEST HANDLING, AND STORAGE ENVIR. TURNAROUND- COUPLINGS WILL BE VISUALLY INSPECTED FOR EVIDENCE OF SEAL DAMAGE AND CAP LEAKAGE. (COUPLINGS BETWEEN THE HELIUM ISOL VALVE & REGULATOR & THOSE ASSOCIATED WITH PROP TANK C/O ARE NOT ACCESSIBLE AT SERVICING PANELS) (D) APOLLO FAILURE HISTORY WAS IN THE MAIN ASSOC WITH GROUND USAGE, IMPROPER HANDLING.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-201095-2

ITEM He Quad Check Valve FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [ ] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1 & 2. Upon using the thrusters, propellant tank ullage pressure will decay until < 200 psi which will give a class 2 alarm, caution and warning. (Red Light)

FMEA NO. SC-24 -[illegible] SC/SRL/[illegible]

ASSY: [illegible] CRIT. PARA. [illegible]

CRIT. FUNC. [illegible]

MISSIONS: PF [illegible]

PHASE(S): PL [illegible]

NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE: [illegible]

REDUNDANCY SCREENS: [illegible]

FAIL TO OPERATE: [illegible] MINUTES

INTERFACE LOCATIONS:

MS521-0054

MS570-0001-0[illegible]

SS72-1H-0103-2

VS70-[illegible]

QUANTITY: 8 OPERATIONAL IN FLIGHT, [illegible]

REDUNDANT TRANSMISSION?.....YES

I/O AT TEST PORTS AND EQUIP

PREPARED BY: DES R. CLERKHART

REL C. MYERS

APPROVED BY: NASA _____

REL _____

ITEM: VALVE, SOLA, CHECK, REG.

CV 10172 -21-1/2CP

FUNCTION:

FOUR CHECK VALVE SOLA PLUS 4 POPPETS IN SERIES - PARALLEL ARRANGEMENT PROVIDES PARALLEL REDUNDANCY FOR HELIUM PRESSURIZATION AND SERIES REDUNDANCY TO LIMIT BACK FLOW OF PROPELLANT VAPORS FROM THE PROPELLANT TANKS TO THE REGULATOR. A 5.0 TO MICRON FILTER IS UTILIZED AT THE INLET. VALVE UTILIZES CUTTER SEAL BOSTON CONCEPT (TWO SEALING SURFACES PER POPPET)

FAILURE MODE: FAILS CLOSED (F)

RESTRICTED FLOW.

CAUSE(S):

STRUCT FAILURE, STUCK, VIB, POPPET BINDS IN GUIDE, CONTAM, VAPOR RELEASES IN COLD VALVE, CORROS.

EFFECT(S): ON (A)SUBSYS (B) (E)INTERFACES (C)MISSION (D)CREW/VEHICLE:

(A) LOSS OF REDUNDANCY - PARAL FLOW PATH. (B,C,D) NO EFFECT UNLESS PARAL POPPETS FAIL CLOSED. FAILURE OF PARAL POPPETS WOULD CAUSE MIX RATIO SHIFT AND POSSIBLY PREVENT UTIL/DEPLETION OF ALL PROP (PROPELLANTS SYMMETRICALLY UNSEAT). (E) POTENTIAL CRITICALITY EFFECT - MISSION & VEHICLE LOSS. FAILURE OF PARALLEL POPPETS WOULD POSSIBLY RESULT IN INABILITY TO BURN OR DEPLETE ALL RCS PROPELLANT IN ADDITION TO STATION KEEPING PROBLEMS WITH RESULTANT THRUSTER FIRING PROBLEMS. POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO UTILIZE RESERVE PROPELLANT AND C.G. PROBLEMS DUE TO PROPELLANT WEIGHT.

OPERATING ACTION:

IF PRESS IPP IS PREDICTED, CLOSE HELIUM ISOL VALVE & UTILIZE CLEARANCE SEALS UNTIL POPPET UNSEATS.

REMARKS/HAZARDS:

ENG HAZ IF PROP NOT DEPLETED PRIOR TO LAUNCH. POSS CHANGE IN PROP LEAK MAY CAUSE HARD START. FAILURE NOT DETECTABLE UNLESS PARAL POPPETS

[illegible]

SUBSYSTEM :AFT - REACTION CONTROL
.ASSEMBLY :PRESSURIZATION
.P/N RI :MC284-0481-0001/-0002
.P/N VENDOR:RS010500-001-011
.QUANTITY :4
. :ONE PER HELIUM SUPPLY
. :

FMEA NO 03-2A-201095-2 REV:12/12/79
ABORT: CRIT. FUNC: 1R
CRIT. HDW: 3
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO X OC X DO X LS

REDUNDANCY SCREEN: A-PASS B-FAIL C-PASS

.PREPARED BY:
.DES R. BURKHART
.REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY (NASA):
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: VALVE, QUAD, CHECK, HE.
. CV 201/202/301/302
.FUNCTION:
. EACH CHECK VALVE QUAD WITH 4 POPPETS IN SERIES - PARALLEL ARRANGEMENT PROVIDES PARALLEL REDUNDANCY FOR HELIUM PRESSURIZATION AND SERIES REDUNDANCY TO LIMIT BACK FLOW OF PROPELLANT VAPORS FROM THE PROPELLANT TANKS TO THE REGULATOR. A 304L 25 MICRON FILTER IS UTILIZED AT THE INLET. VALVE UTILIZES CUTTER SEAL DESIGN CONCEPT (TWO SEALING SURFACES PER POPPET)
.FAILURE MODE: FAILS CLOSED (F)
. RESTRICTED FLOW.
.CAUSE(S):
. STRUCT FAILURE, SHOCK, VIB, POPPET BINDS IN GUIDE, CONTAM, VAPOR FREEZES IN COLD VALVE, CORROS.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF REDUNDANCY - PARAL FLOW PATH. (B,C,D) NO EFFECT UNLESS PARAL POPPETS FAIL CLOSED. FAILURE OF PARAL POPPETS WOULD CAUSE MIX RATIO SHIFT AND POSSIBLY PREVENT UTIL/DEPLETION OF ALL PROP (POPPETS EVENTUALLY UNSEAT). (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW VEHICLE LOSS. FAILURE OF PARALLEL POPPETS WOULD POSSIBLY RESULT IN INABILITY TO BURN OR DEPLETE ALL RCS PROPELLANT IN ADDITION TO MIXTURE RATIO PROBLEMS WITH RESULTANT THRUSTER FIRING PROBLEMS. POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO UTILIZE RESERVED PROPELLANT AND C.G. PROBLEMS DUE TO PROPELLANT WEIGHT.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) SERIES-PARALLEL REDUNDANT POPPETS PROVIDE REDUNDANCY FOR THE CLOSED FAILURE MODE. TO LIMIT THE POTENTIAL FOR POPPET SHAFT BINDING, OR GENERATION OF CONTAMINATION THE GUIDE PINS UTILIZE SAPPHRE AS A WEAR RESISTANT SURFACE. A 25-MICRON INLET FILTER WILL ALSO REDUCE THE POTENTIAL FOR A CLOSED FAILURE BY LIMITING THE POTENTIAL FOR CONTAMINATION TO CAUSE BINDING OF MOVING PARTS. (B) 100,000 OPERATION CYCLES (FLOW) AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITIONS. PROOF PRESSURE, LEAKAGE, & OPERATION (CRACKING PRESSURE AND FLOW) TESTS ARE PEFORMED DURING ATP. APPROPRIATELY LOCATED TEST POINTS ALLOW PRE/POST FLIGHT LEAKAGE TESTS AND OPERATION TESTS WHICH ARE CONDUCTED AT THIS TIME. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -201095-2 REV:12/12/75
CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, MDE EXAM. OF WELDS AND BRAZES, INSP. FOR SURFACE AND SUBSURFACE DEFECTS ARE VERIFIED BY INSPECTION. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP. POINTS - RAW MTL (LOT CERTIFICATION), PARTS PROTECTION, MANUF., COATING, PLATING INSTALLATION AND ASSEMBLY OPERATINS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 12-2-77. CONTAMINATION CONTROL PROCESSES, CORROS. PROTECTION PROVISIONS. TURNAROUND - FUNCTIONAL FLOW AND LEAKAGE (BACK-FLOW) TESTS ARE PERFORMED. (D) NO PRIOR HISTORY FOR CLOSE FAILURE MODE FOR THIS TYPE OF DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202108-1

ITEM Feedline & Fittings, Fuel FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In-flight detectability

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection gives first indication.

2. V42P2115 and 3115 should be deleted from this FMEA page as they are in the oxidizer system and not the fuel system.

[illegible]

.[illegible] - PROPELLANT CONTROL — PART NO OR P/A - [illegible] — REVISED/[illegible]
.SYSTEM: PROPELLANT FEED & FUEL — ASSY: — CRIT. FUNC: [illegible]
.P/A NOMENCLATURE: [illegible] — CRIT. ITEM: [illegible]
. QUANTITY: 2 — MISSIONS: ME VE [illegible] — FAILURE MODE (S): PE LE [illegible]
. 1 PER SYSTEM — NUMBER OF SUCCESS PATHS REMAINING:
. [illegible] — APPLICABLE PHASE(S):
. REDUNDANCY SCREEN: A-YES B-YES C-YES
.FAILURE DETECTABLE IN FLIGHT: YES — IOC: [illegible]
.METHOD: [illegible] — VAC-ELECTRIC CHEC — SECOND TO RECOVER:
.FAILURE EFFECT — REMARKS AND JUSTIFICATION:
. — VS76-[illegible]
.GROUND TURNAROUND?.....YES — PD 76-[illegible]
.ALL ABOVE — PRE-FLIGHT VISUAL CHECK — SD72-SH-0105-[illegible]
. — ML621-[illegible]

PREPARED BY: — APPROVED BY:
DES — [illegible] CLAVINICH — DES _____
REL — C MARKS — REL _____

.ITEM: PROPELLANT FEED LINES
. P/N [illegible] (1) TANK VALVES, (2) MANIFOLD VALVES, (3) REGULATORS.
.FUNCTION:
. (1) 1 1/2 X.025 304 L S.S. PROP. TANK TO DISTRIBUTION PANEL, (2) 1 1/2 X.035 304 L S.S. MANIFOLD ISOLATION VALVE TO THRUSTER ASSEMBLIES, (3) 1/4 X.035 INCONEL MANIFOLD TO PROVIDE FEED TO APPROPRIATE PROPELLANT COMPONENTS FOR ORBITER OPERATIONS AXIS ACCELERATION CONTROL AND ROTATIONAL CONTROL.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. RUPTURE, EXTERNAL LEAKAGE.
.CAUSE(S):
. WELD, FATIGUE, STRESS, MATERIAL DEF, INSTALL DAM, DYNAMIC SEAL FAILURE, MATERIAL (SOLDERED STRINGER).
.EFFECT(S): (A) (W)SUBSYSTEM (S)INTERFACE (C)MISSION (L)OSS/VEHICLE:
. (A) SUBSYSTEM DEGRADATION - LOSS OF PROP. (B) DEGRADATION OF
. INTERFACE FUNCTION - FUEL CONTROL DAMAGE IN POD. (C) LAUNCH DELAY OR ABORT DECISION. (L) POSSIBLE LOSS OF CREW/VEHICLE-IF LEAK ENDS TANK OUTLET PRESSURE - RESULTS IN INABILITY TO UTILIZE/[illegible] PROP. [illegible] WITH FUEL - MAY CAUSING FIRE OR EXPLOSION.
.CORRECTIVE ACTION:
. ISOLATE LEAK USING MANIFOLD OR TANK ISOL VALVES. UTILIZE GMS PROP AS REQ'D. ABORT MAY BE REQ'D.
.REMARKS/HAZARDS:
. PRE FIRE, EXPLOS, TOX & CORROS HAZ FROM FUEL PROP IN POD. NO ACCESS PROV. SOME LEAK POINTS MAY NOT BE ISOLATABLE (UPSTREAM OF TANK ISOL VALVES. DECOMP OF FUEL NOT CAUSE BELOW 800F UNLESS AIR OR CATALYST PRESENT. MAX HEAT SHIELD TEMP (INSIDE) IS 350F. REF HAZ NO 1YXX-[illegible]-A.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO. 03-2A -202108-1 REV:11/08/7?
.ASSEMBLY :PROPELLANT FEED, FUEL ABORT: CRIT. FUNC: 1
.P/N RI :MC621-0059 CRIT. HDW: 1
.P/N VENDOR:73A560001 MISSIONS: HF VF X FF OF SM
.QUANTITY :2 PHASE(S): PL LO X CO X OO X LS
. :ONE SET PER PROPELLANT
. :PER MODULE
. REDUNDANCY SCREEN: A-N/A B-N/A C-N/A
.
.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES N G GLAVINICH DES SSM
.REL C M AKERS REL REL
.
.
APPROVED WITH CHANGES
See Section 13.0

.ITEM: FEEDLINE AND FITTINGS
. FROM TANK TO 1) TANK VALVES, TO 2) MANIFOLD VALVES, TO 3) THRUSTERS.
.FUNCTION:
. (1) 1 1/2 X.028 304 L S.S. FROM TANK TO DISTRIBUTION PANEL, (2) 1 1/4 X.028 FROM MANIFOLD ISOLATION VALVE TO THRUSTER MANIFOLD, (3) 5/8 X.028 THRUSTER MANIFOLD TO PROVIDE FEED TO APPROPRIATE PROPELLANT COMPONENTS FOR THRUSTER OPERATION-3 AXIS ACCELERATION CONTROL AND ROTATIONAL CONTROL.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. RUPTURE, EXTERNAL LEAKAGE.
.CAUSE(S):
. VIB, FATIGUE, SHOCK, WELD DEF, INSTALL DAM, DYNATUBE SEAL FAILURE, MAT' DEF (SULPHIDE STRINGER).
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) SUBSYSTEM DEGRADATION - LOSS OF PROP. (B) DEGRADATION OF INTERFACE FUNCTION - POSS CORROS DAMAGE IN POD. (C) LAUNCH DELAY OR ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE-IF LINE FROM TANK OUTLET RUPTURES RESULTING IN INABILITY TO UTILIZE/DEPLETE PROP OR PROP REACTS WITH FUEL OR OX CAUSING FIRE OR EXPLOSION.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 1.5 TO 4.0 MAXIMUM OPERATING PRESSURE (SYSTEM RELIEF). DYNATUBES HAVE DUAL SEALING SURFACES. THE WELDED CONSTRUCTION ELIMINATES JOINTS AND POSSIBLE LEAK PATHS. THE ANNEALED AREA (DUE TO WELDING) IS BACKED UP BY A SLEEVE. FASTENING CLAMPS ALLOW FREEDOM OF MOVEMENT. TUBING BENDS ARE CONTROLLED BETWEEN FIXED POINTS TO FACILITATE INSTALLATION AND ACCOMMODATE VEHICLE GROWTH AND MOVEMENT. (B) ROCKWELL PERFORMED TUBING CERTIFICATION TESTS PER "ORBITER TUBING VERIFICATION PLAN" (SD 75-SH-0205). THIS TESTING INCLUDED PRESSURE CYCLING AND FATIGUE FOR TYPICAL SHUTTLE LINES & JOINTS. SYSTEM EVALUATION TESTS AT WSTF WILL ALSO ALLOW EVALUATION IN THE INSTALLED SYSTEM CONDITION. LEAKAGE TESTS ARE PERFORMED IN-PROCESS FOR TUBING SECTIONS. OPTICAL INSPECTIONS ARE ALSO PERFORMED AT THIS TIME IN ADDITION TO X-RAY AND DYE PENETRANT. LEAKAGE TESTS ARE ALSO PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND ADDITIONAL WELDS ARE ALSO SUBJECTED TO NDE. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAM. CONTROL PROCESSES, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS AND INSP. FOR SURFACE AND SUB-SURFACE DEFECTS IS VERIFIED BY INSPECTION. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202108-1 REV:11/03/78
MANDATORY INSP. POINTS- RAW MAT'L (LOT CERTIFICATION), PARTS PROTECTION, MANUF., COATING, PLATING, INSTALLATION AND ASSEMBLY OPERATIONS. HARDWARE IS INSP. IN ACCORDANCE WITH QUALITY PLANNING REQMTS DOCUMENT (QPRD) WHICH HAS BEEN APPROVED BY NASA. TURNAROUND- LINES IN ACCESSIBLE AREAS ARE VISUALLY INSPECTED FOR EVIDENCE OF DAMAGE AND FLOW AND PRESSURE FUNCTIONAL TESTS ARE MONITORED FOR EVIDENCE OF OBSTRUCTION OR LEAKAGE. (D) MINOR HISTORY - CORROSION/FAB PROBLEMS DETECTED DURING APPOLLO CHECKOUT AND CORRECTED.
CORRECTED.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202109-1

ITEM Feedline & Fittings, OX FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X]	NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X]	*1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ]	*NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES.
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection gives first indication.

CRITICAL FAILURE MODE AND EFFECTS ANALYSIS - CONTINUED

SUBSYSTEM: REACTION CONTROL
ASSY: PROPELLANT DISTRIBUTION
ITEM: SET PER PROPELLANT

FMEA NO: [illegible]
ALERT:
MISSION(S): PRE [illegible]
PHASE(S): PRE [illegible]
NUMBER OF SUCCESS PATHS REMAINING:
AFTER FIRST FAILURE:
SUBSEQUENTLY SCREENED:

CRITICALITY: 1/1
CRIT. FUNC:
CRIT. ITEM:

CRITICALITY: 1/1R
CAN ITEM BE REMOVED IN FLIGHT? YES
TANK PRESSURE V-[illegible] IF ANY 3210

TIME TO EFFECT:
FINDS:
REFERENCE DOCUMENTS:
VS70-[illegible]
MJ070-[illegible]
SL72-[illegible]
MC621-[illegible]

CAN BE DUPLICATED?.....YES
AS FLIGHT INSTRUMENTATION

PREPARED BY: [illegible] M C GLAVINICH
[illegible] C M AKERS

APPROVED BY:
[illegible] _____
[illegible] _____

FAILURE MODE AND EFFECTS
[illegible] 1 2) TANK VALVES TO 2) MANIFOLD VALVES TO 3) THRUSTERS.
FAILURE:
(A) 1 1/2 [illegible] SCALE SIZE FROM TANK TO DISTRIBUTION PANEL, (B) 1 1/2 [illegible] FROM ANNULAR ISOLATION VALVE TO THRUSTER MANIFOLD (C) 3/4 [illegible] THRUSTER MANIFOLD TO PROPELLANT HELD TO APPROPRIATE PROPELLANT CONSISTENT WITH THRUSTER OPERATION - 3 AXIS ACCELERATION, TRANSLATIONAL AND ROTATIONAL CONTROL.
FAILURE MODE: STRUCTURAL FAILURE (S)
RUPTURE, EXTERNAL LEAKAGE.
CAUSE(S):
MECHANICAL SHOCK, VIBRATION/FATIGUE, IMPROPER INSTALLATION (WELD). MATERIAL FLAW FAILURE WITH DEFICIENCY (SULPHIDE STRINGERS).
EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) SUBSYSTEM DEGRADATION - LOSS OF PROPELLANT. (C) DEGRADATION OF REACTION FUNCTION - POTENTIAL CORROSION FROM FREE PROPELLANTS IN [illegible]. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW VEHICLE - IF LINE BURST FANS (TOILET RUPTURES) RESULTING IN INABILITY TO UTILIZE/CONTROL [illegible] OF PROPULSION FUEL [illegible] OR CATASTROPHIC COLLISION WITH OR EXPLOSION.
CORRECTIVE ACTION:
ATTEMPT TO ISOLATE AND INITIATE ABORT. UTILIZE GMS PROPELLANT AS REQUIRED. ABORT DECISION MAY BE REQ'D.
REMARKS/HAZARDS:
POTENTIAL TOXIC & CORROSIVE HAZARD FROM FREE PROPELLANTS. SOME LEAK POINTS MAY NOT BE ISOLATABLE (UPSTREAM OF TANK ISOLATION VALVES). REF MMC NO 1YXA-02G2-CF.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202109-1 REV:11/03/78
.ASSEMBLY :PROPELLANT FEED,OXIDIZER ABORT: CRIT. FUNC: 1
.P/N RI :MC621-0059 CRIT. HDW: 1
.P/N VENDOR:73A560002 MISSIONS: HF VF X FF OF SM
.QUANTITY :2 PHASE(S): PL X LO X CO X DO X LS X
. :ONE SET PER PROPELLANT
. :

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES N C GLAVINICH DES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: FEEDLINE AND FITTINGS
. FROM TANK TO 1) TANK VALVES TO 2) MANIFOLD VALVES TO 3) THRUSTERS.
.FUNCTION:
. (1) 1 1/4 X.028 304L S.S. FROM TANK TO DISTRIBUTION PANEL, (2) 1 1/2 X.028 FROM MANIFOLD ISOLATION VALVE TO THRUSTER MANIFOLD (3) 3/4 X.028 THRUSTER MANIFOLD TO PROVIDE FEED TO APPROPRIATE PROPELLANT COMPONENTS FOR THRUSTER OPERATION - 3 AXIS ACCELERATION CONTROL AND ROTATIONAL CONTROL.
.FAILURE MODE: STRUCTURAL FAILURE (S)
. RUPTURE, EXTERNAL LEAKAGE.
.CAUSE(S):
. MECHANICAL SHOCK, VIBRATION/FATIGUE, IMPROPER INSTALLATION (WELD). DYNATUBE SEAL FAILURE MAT'L DEFICIENCY (SULPHIDE STRINGER).
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) SUB-SYSTEM DEGRADATION - LOSS OF PROPELLANT. (B) DEGRADATION OF INTERFACE FUNCTION - POTENTIAL CORROSION FROM FREE PROPELLANTS IN MODULE. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW VEHICLE - IF LINE FROM TANK OUTLET RUPTURES RESULTING IN INABILITY TO UTILIZE/DEPLETE PROP OR PROP REACTS WITH FUEL OR OXIDIZER CAUSING FIRE OR EXPLOSION.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) F.S. IS 1.5 TO 4.0 MAXIMUM OPERATING PRESSURE (SYSTEM RELIEF). DYNATUBES HAVE DUAL SEALING SURFACES. THE WELDED CONSTRUCTION ELIMINATES JOINTS AND POSSIBLE LEAK PATHS. THE ANNEALED AREA (DUE TO WELDING) IS BACKED UP BY A SLEEVE. FASTENING CLAMPS ALLOW FREEDOM OF MOVEMENT. TUBING BENDS ARE CONTROLLED BETWEEN FIXED POINTS TO FACILITATE INSTALLATION AND ACCOMMODATE VEHICLE GROWTH AND MOVEMENT. (B) ROCKWELL PERFORMED TUBING CERTIFICATION TESTS PER "ORBITER TUBING VERIFICATION PLAN" (SD75-SH-0205). THIS TESTING INCLUDED PRESSURE CYCLING AND FATIGUE FOR TYPICAL SHUTTLE LINES & JOINTS. SYSTEM EVALUATION IN THE INSTALLED SYSTEM CONDITION. LEAKAGE TESTS ARE PERFORMED AT THIS TIME IN ADDITION TO X-RAY AND DYE PENETRANT. LEAKAGE TESTS ARE ALSO PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND ADDITIONAL WELDS ARE ALSO SUBJECTED TO NDE. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAM. CONTRCL PROCESSES, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS AND INSP. FOR SURFACE AND SUB-SURFACE DEFECTS IS VERIFIED BY INSPECTION. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP. POINTS- RAW MAT'L (LOT

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202109-1 REV:11/03/7?
CERTIFICATION, PARTS PROTECTION, MANUF., COATING, PLATING, INSTALATION AND ASSEMBLY OPERATIONS. HARDWARE IS INSP. IN ACCORDANCE WITH QUALITY PLANNING REQMITS DOCUMENT (QPRD) WHICH HAS BEEN APPROVED BY NASA. TURNAROUND- LINES IN ACCESSIBLE AREAS ARE VISUALLY INSPECTED FOR EVIDENCE OF DAMAGE AND FLOW AND PRESSURE FUNCTIONAL TESTS ARE MONITORED FOR EVIDENCE OF OBSTRUCTION OR LEAKAGE. (D) MINOR HISTORY - CORROSION/FAB PROBLEMS DETECTED DURING APPOLLO CHECKOUT AND CORRECTED. ARE MONITORED FOR EVIDENCE OF OBSTRUCTION OR LEAKAGE. (D) MINOR HISTORY - CORROSION/FAB PROBLEMS DETECTED DURING APPOLLO CHECKOUT AND CORRECTED.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202110-1

ITEM Tank Isolation Valve, A.C. FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X] *NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ] *NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. First indication "failed off" thruster C&W for 1/2 leg. Redundant paths on 3,4,5 leg.

3A. Software could be designed to automatically position the appropriate tank isolation valve.

6. One success path remains after first failure.

8B. Same as primary.

[illegible] SYSTEM: [illegible] - [illegible] CODE: [illegible]
ASSY LEV: PROPELLANT FEED
SUBSYS: [illegible]
VENDOR: [illegible]
QUANTITY: 16
: TANK VALVES FOR FROM
: TANK
PHASE NO & TYPE: [illegible]
CRIT: FLIGHT, [illegible] CRIT. FAC: 2
[illegible] CRIT. FAC: 2
DISSIMILAR: NO [illegible]
REMARKS: [illegible]
NUMBER OF SUCCESS PATHS REMAINING:
PRIMARY FAILURE:
REDUNDANCY SCREEN: A-PASS, B-PASS, C-PASS
CRITICAL ITEM: YES
INTERFACE PRESSURE VENT- TOP, INDUSTRY CHARGER
FILLER AND VALVE POSITION INDICATION
GROUND TURNAROUND.....YES
SAME AS FLIGHT
FAIL SAFE: [illegible]
MISSION: [illegible]
MDAC-[illegible]
SPEC-[illegible]
VSFS-[illegible]

PREPARED BY: R GONZALEZ
REL C M AYERS
APPROVED BY: SES _____
REL _____

TITLE: VALVE,
TANK ISOLATION, 3 PHASE 400 HZ AC MOTOR ACTUATED (115-2 PH) LV101-[illegible], LV [illegible]
FUNCTION:
TWO REDUNDANT ISOLATION VALVES ARE USED FOR EACH TANK TO ISOLATE MAJOR SUBSYSTEMS (ONE TANK ISOL VALVE CONTROLS 2 MANIFOLDS AND ONE PROPELLANT ISOL VALVE CONTROLS THE OXIDIZING & FUEL PRIMARY MANIFOLDS AND THE VERNIER MANIFOLD) THAT MAY EXPERIENCE OPEN OR LEAKAGE FAILURES AND TO ISOLATE THE TANK DURING INTERCONNECT & ASE IN CASE CROSSFEED OPERATION. ALSO USED TO PREVENT PROPELLANT MIGRATION IN ORBIT AT PROP MANAGEMENT (MANUAL CLOSED). FUEL & OXID VALVES CAN BE OPERATED INDEPENDENTLY FOR C/G. TANK PRESS RELIEF TO TANK IS PROVIDED.
FAILURE MODE: FAILS CLOSED (F)
FAILS TO OPEN, FAILS TO REMAIN OPEN.
CAUSE (S):
LIMIT SWITCH MALFUNCTION, PREMATURE POWER TO MOTOR, ELECTRICAL SHORT, MECH OPEN, JAMMING OF BALL SHAFT OR CAMS.
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE :
(A) LOSS OF REDUNDANCY PROPELLANT FED TO ITS MANIFOLDS (ONE OX & ONE FUEL) AND SUBSEQUENT LOSS OF MANEUVER FUNCTION, POTENTIAL IMPACT & CASUALTY FROM INFLIGHT SURGE. (C) ABORT DECISION DEPENDENT ON WHICH TANK ISOL VALVE FAILS, ONE TANK ISOL VLV CLOSED MAY LOSE TWO MANIFOLDS). (D) NO EFFECT FOR SINGLE FAILURE PER MPT MISSIONS (LOSS OF MANIFOLDS MAY BE CRITICAL FOR MISS IN SUBSEQUENT MISSIONS FOR GAS DEPLETION CONSI). CRIT) FOR FAIL - LOSS OF TWO MANIFOLDS (PER PROP MGT) IS CRITICAL FOR ET SEPARATION & MATED COAST DURING ABILS. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS DUE TO UTILIZE/DEPLETE ACS PROPELLANT. POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO UTILIZE RESERVED PROPELLANT & C.G. PROBLEMS DUE TO PROP WEIGHT.
CORRECTIVE ACTION:

[illegible]

- [illegible]
- [illegible]

SUBSYSTEM :AFT - REACTION CONTROL
.ASSEMBLY :PROPELLANT FEED
.P/N RI :MC284-0430-0007/-0008
.P/N VENDOR:5750025/5750026
.QUANTITY :12
. :THREE VALVES PER PROP
. :TANK

FMEA NO 03-2A -202110-1 REV:12/12/78
ABORT: ABORT, CRIT. FUNC: 1R
RTLS CRIT. HDW: 2
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO X CO X DO X LS

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

.PREPARED BY:
.DES R GONZALEZ
.REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY NASA:
SSM
RQA

APPROVED WITH CHANGES
See Section 13.0

.ITEM: VALVE.
. TANK ISOLATION 3 PHASE 400 HZ AC MOTOR ACTUATED (115-200V) LV261-266, LV 361-366. (1-1/2 IN.)
.FUNCTION:
. THREE REDUNDANT ISOLATION VALVES ARE USED PER TANK TO ISOLATE GROUPS OF MANIFOLDS (ONE TANK ISOL VALVE CONTROLS 2 MANIFOLDS AND TWO PARALLEL ISOL VALVES CONTROL THE REMAINING 2 PRIMARY MANIFOLDS AND THE VERNIER MANIFOLD) THAT MAY EXHIBIT OPEN OR LEAKAGE FAILURES AND TO ISOLATE THE TANK DURING INTERCONNECT S RCS OR OMS CROSSFEED OPERATIONS. ALSO USED TO PREVENT HELIUM INGESTION TO ENGINE AT PROP RUN-OUT (MANUAL SWITCH). FUEL & OXID VALVES CAN BE OPERATED INDEPENDENTLY FOR C/O. LINE PRESS RELIEF TO TANK IS PROVIDED.
.FAILURE MODE: FAILS CLOSED (F)
. FAILS TO OPEN, FAILS TO REMAIN OPEN.
.CAUSE(S):
. LIMIT SWITCH MALFUNCTION, PREMATURE POWER TO MOTOR, ELECTRIAL SHORT, RPC OPEN, JAMMING OF BALL SHAFT OR CAMS.
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A,B) LOSS OF REDUNDANCY PROPELLANT FLOW TO TWO MANIFOLDS (ON ONE SIDE) AND SUBSEQUENT LOSS OF THRUSTER FUNCTION, POTENTIAL THRUSTER DAMAGE FROM INDUCED SURGE. (C) ABORT DECISION (DEPENDENT ON WHICH TANK ISOL VALVE FAILS, ONE TANK ISOL VLV CLOSED MAY LOSE TWO MANIFOLDS). (D) NO EFFECT FOR SINGLE FAILURE FOR OFT MISSIONS (LOSS OF THRUSTER MAY BE CRITICAL FOR RTLS IN SUBSEQUENT MISSIONS FOR OMS DEPLETION BURN). CRIT 1 FOR RTLS - LOSS OF TWO MANIFOLDS (PER POD AFT) IS CRITICAL FOR ET SEPARATION & MATED COAST DURING RTLS. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICAL LOSS DUE TO UTILIZE/DEPLETE RCS PROPELLANT. POSSIBLE INABILITY TO CONTROL VEHICLE DURING ENTRY DUE TO INABILITY TO UTILIZE RESERVED PROPELLANT & C.G. PROBLEMS DUE TO PROP WEIGHT.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) AC MOTOR VALVE IS 3-PHASE - 2 OF 3 WINDINGS ARE ADEQUATE FOR VALVE FUNCTION. SERIES (HYBRID) RELAYS PROVIDE REDUNDANCY FOR THE PREMATURE CLOSE MODE. PARALLEL (HYBRID) RELAYS PROVIDE REDUNDANCY FOR ELECTRICAL POWER SIGNAL. ADDITIONALLY, REDUNDANT VALVES ARE PROVIDED.(ONE TANK ISOL VALVE CONTROLS 2 OF 4 MANIFOLDS AND TWO PAALLEL TANK ISOL VALVES CONTROL THE REMAINING 2 PRIMARY MANIFOLDS AND THE VERNIER MANIFOLD). A 400-MICRON FILTER IS UTILIZED ON THE INLET AND OUTLET TO LIMIT THE POTENTIAL FOR CONTAMINATION CAUSED FAILURE OR JAMMING OF MOVING PARTS.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202110-1 REV:12/12/78

(B) 2500 OPERATION CYCLES (OPEN-CLOSE-OPEN) AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITION. PROOF PRESSURE, LEAKAGE, OPERATION, CONDUCTED AS PART OF PRE/POST FLIGHT CHECKOUT. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED. CONTAMINATION CONTROL PROCESS, CORRO. PROTECTION PROVISIONS, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS AND PROPER ELECTRICAL TERMINATIONS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED JULY 1976/ CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND/FUNCTIONAL FLOW & LEAKAGE TESTS ARE MONITORED TO VERIFY THAT VALVES OPEN AND CLOSE PROPERLYUPON COMMAND. (D) NO PRIOR FAILURE HISTORY FOR THIS TYPE DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202110-3

ITEM Tank Isolation Valve, A. C. FAILURE MODE Fails Open

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [ ] NO [X]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X] *NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1A. Tank isolation valve discreets are available.

.SYSTEM : RCS - REACTION CONTROL
.ASSY LVL : PROPELLANT FEED
.P/N : [illegible]
.P/N NOMEN: TANK,SURGE
.QUANTITY :
: TWO* VALVES PER PROP
: TANK

FMEA NO.: [illegible]
CRIT: 1R2S
REL
MISSIONS: MF
PHASE(S): PL
NUMBER OF SUCCESS PATH SCENARIOS
AFTER FIRST FAILURE:
REDUNDANCY SCREEN: A-PASS B-PASS C-[illegible]
TIME TO EFFECT:
CRITICAL
REFERENCE DOCUMENTS:
MC621-0009
MJ070-0001-01H
S072-SH-01C8-A
VS7C-451601

.FAILURE OUT STAGE IN FLIGHT?. YES
.CRITICAL TANK PRESSURES /VOL POSITION INDICATORS

.RESPONSE TURNAROUND?.....YES
.STAGE AS FLIGHT

PREPARED BY:
DES R GONZALEZ
REL C W AKERS

APPROVED BY:
DES _____
REL _____

.ITEM: VALVE
. TANK ISOLATION 3 PHASE 400 HZ AC MOTOR ACTUATED (115-200V) [illegible]
. [illegible]
.FUNCTION:
. FOR EACH OF TWO PROPELLANT ISOLATION VALVES ARE USED PER TANK TO ISOLATE GROUPS OF MANIFOLDS (ONE TANK ISOL VALVE CONTROLS 2 MANIFOLDS AND THE REMAINING ISOL VALVES CONTROL THE REMAINING 2 PRIMARY MANIFOLDS AND THE VERNIER MANIFOLD) THAT MAY EXPERIENCE OPEN OR LEAKAGE FAILURES AND TO ISOLATE THE TANK DURING INTERCONNECT & RCS OR OMS CROSSFEED OPERATIONS. ALSO USED TO PREVENT PROPELLANT MIGRATION TO ENGINE AT PROP EXHAUST (ZERO-G SETTLING). FUEL & OXID VALVES C/W TO BE OPERATED INDEPENDENTLY PER C/T. LINE PURGE RELIEF TO TANK IS PROVIDED.
.FAILURE MODE: INTERNAL LEAKAGE (F)
. FAILS OPEN, FAILS TO CLOSE, FAIL TO REMAIN CLOSED.
.CAUSE(S):
. VIBRATION, LIMIT SWITCH MALFUNCTION, STRUCTURAL FAILURE, SEAT DAMAGE CONTAMINATION, CORROS, LOSS OF SIGNAL (COIL, REC SPOOLS OR CIRC).
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (,) LOSS OF REDUNDANCY - (MANIFOLD ISOLATION). (C) ABORT - [illegible]
. PROPELLANT MANAGEMENT PROBLEMS DURING CROSSFEED OPERATIONS. (D) NO EFFECT - CRIT 1 FOR RTLS. IF RCS TANK ISOLATION VALVE WILL NOT CLOSE DURING OMS DEPLETION BURN THE RCS PROPELLANT MAY BE DEPLETED IF ASSOC MANIFOLD ISOLATION VALVES ARE NOT CLOSED.
.CORRECTIVE ACTION:
. MAY NEED TO INHIBIT CROSSFEED OPERATIONS TO PREVENT TRANSFER OF PROPELLANTS BETWEEN RCS OR OMS PROP INTO RCS PROP TANK.
.REMARKS/RATIONALE:
. ITEM UPGRADED FROM CRIT 3 TO CRIT 2 PER NASA REQUEST.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202110-3 REV:12/12/73
.ASSEMBLY :PROPELLANT FEED ABORT: ABORT, RTLS CRIT. FUNC: 2
.P/N RI :MC234-0430-0007/-0008 CRIT. HDW: 2
.P/N VENDOR:5750025/5750026 MISSIONS: HF VF X FF CF SM
.QUANTITY :12 PHASE(S): PL LO X CC X DO X LS
. :THREE VALVES PER PROP
. :TANK

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES R.GONZALEZ R.G. DES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: VALVE.
. TANK ISOLATION 3 PHASE 400 HZ AC MOTOR ACTUATED (115-200V) LV261-266, LV 361-366.
.FUNCTION:
. THREE REDUNDANT ISOLATION VALVES ARE USED PER TANK TO ISOLATE GROUPS OF MANIFOLDS (ONE TANK ISOL VALVE CONTROLS 2 MANIFOLDS AND TWO PARALLEL ISOL VALVES CONTROL THE REMAINING 2 PRIMARY MANIFOLDS AND THE VERNIER MANIFOLD) THAT MAY EXHIBIT OPEN OR LEAKAGE FAILURES AND TO ISOLATE THE TANK DURING INTERCONNECT & FCS OR OMS CROSSFEED OPERATIONS. ALSO USED TO PREVENT HELIUM INGESTION TO ENGINE AT PROP RUN-OUT (MANUAL SWITCH). FUEL & OXID VALVES CAN BE OPERATED INDEPENDENTLY FOR C/O. LINE PRESS RELIEF TO TANK IS PROVIDED.
.FAILURE MODE: INTERNAL LEAKAGE (F)
. FAILS OPEN, FAILS TO CLOSE, FAIL TO REMAIN CLOSED.
.CAUSE(S):
. VIBRATION, LIMIT SWITCH MALFUNCTION, STRUCTURAL FAILURE, SEAT CRACKS CONTAMINATION, CORROS, LOSS OF SIGNAL (RPC SHORTS OR OPEN).
.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A,B) LOSS OF REDUNDANCY - (MANIFOLD ISOLATION). (C) ABORT DECISION - PROPELLANT MANAGEMENT PROBLEMS DURING CROSSFEED OPERATIONS. (D) NO EFFECT - CRIT 1 FOR RTLS. IF RCS TANK ISOLATION VALVE WILL NOT CLOSE DURING OMS DEPLETION BURN THE RCS PROPELLANT MAY BE DEPLETED IF ASSOC MANIFOLD ISOLATION VALVES ARE NOT CLOSED.
.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
. (A) AC MOTOR VALVE IS 3-PHASE - 2 OF 3 WINDINGS ARE ADEQUATE FOR VALVE FUNCTION. PARALLEL (HYBRID) RELAYS PROVIDE REDUNDANCY FOR ELECTRICAL POWER SIGNAL. A 400-MICRON FILTER IS UTILIZED ON THE INLET AND OUTLET TO LIMIT THE POTENTIAL FOR CONTAMINATION CAUSED FAILURE OR JAMMING OF MOVING PARTS. (B) 2500 OPERATION CYCLES (OPEN-CLOSE-OPEN) AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMILATED MISSION USAGE CONDITION. PROOF PRESSURE, LEAKAGE, OPERATION, CONDUCTED AS PART OF PRE/POST FLIGHT CHECKOUT. (C) A VISUAL INSP AND IDENTIFICAITON IS PERFORMED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS AND PROPER ELECTRICAL TERMINATIONS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202110-3 REV:12/12/78
VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED JULY 1976/ CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND - FUNCTIONAL FLOW & LEAKAGE TESTS ARE MONITORED TYO VERIFY THAT VALVES OPEN AND CLOSE PROPERLY UPON COMMAND. (D) NO PRIOR FAILURE HISTORY FOR THIS TYPE DESIGN.

SUBSYSTEM APT - RCS FMEA NUMBER 03-2A-20211.1-2

ITEM Interconnect Valve, A. C. FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ] *NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In Flight Detectability
[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed off" thruster gives first indication.

6. One success path remains after first failure.

8B. Same as primary.

ORIGINAL PAGE IS
OF POOR QUALITY

SINGLE FAILURE POINT AND EFFECTS ANALYSIS - CRITICAL ITEMS

SUBSYSTEM: ORBITER - REACTION CONTROL SYSTEM
ITEM NO. AND NOMENCLATURE: V41-2 PROPELLANT VALVE
PART NO.: 10-[illegible]
CRIT. FUNC.: 1R
CRIT. CODE: 1
MISSIONS: ALL
PHASE(S): PL
MODES OF FAILURE: FAILS CLOSED
FAILURE DETECTABLE IN FLIGHT?: YES
INTERFACE WITH: V41S-34[illegible] 34128
REMARKS: 2 REQ'D
1 REQ'D FOR ENTRY
REDUNDANCY SCREEN: A - PASS B - PASS C - PASS
FAIL TO OPERATE:
SECONDARY
REFERENCE DOCUMENTS:
MP21-0001
MVC7-0001-01
CD72-SM-0103-2
VS70-0010-01

PREPARED BY: R GONZALEZ
DES
REL

APPROVED BY:
DES _____
REL _____

ITEM: VALVE.
INTERCONN 01, 3 PHASE 26 VOLT 400 CPS (115-200V), 0.75 AMPS (1.2A).
QTY 471/472/473/474.
FUNCTION:
TO PROVIDE CONTROL OF 1 INTERCONNECT LINE FOR VARIOUS MODES OF PROPELLANT FLOW: 1) OPEN FOR RCS TO RCS 2) OPEN FOR RCS TO RCS 3) CLOSED FOR ISOLATION OF SAME SIDE RCS AND OMS TO OMS. TWO INTERCONNECT VALVES ARE USED IN EACH OMS. EACH WORKS INDEPENDENTLY TO SEPARATE MANIFOLD BANKS. LINE PRESSURE RELIEF TO MAIN PROP TANK IS PROVIDED.
FAILURE MODE: FAILS CLOSED (F)
FAILS TO REMAIN OPEN.
CAUSE(S):
VLV, LIMIT SW FAILURE, PREMATURE POWER TO MOTOR, ELECTRICAL SHORT OPEN, JAMMING OF VLV.
EFFECT(S): ON (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE:
(A) LOSS OF REDUNDANCY. (B) DEGRADATION OF INTERFACE
FUNCTION-CROSSFEED PROP CAN BE UTILIZED BY ONLY 2 OF 4 PROPELLANTS.
(C) MISSION MODIFICATION-OPERATION CHANGES FOR [illegible] ABORT.
[illegible] FOR ABORT MISSIONS (LOSS OF TRANSFER MAY BE CRITICAL FOR RCS IN SUBSEQUENT MISSIONS FOR OMS DEPLETION BURN). CRIT 1 FOR RTLS - LOSS OF 1 MANIFOLD FORWARD & 1 MANIFOLD AFT IS CRITICAL FOR RT SEPARATION & MAIN ENGINE CUTOFF DURING RTLS. SINGLE COMPUTER FAILURE COULD RESULT IN THIS TYPE CONDITION. (D) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE EARLY MISSION TERMINATION - INABILITY TO DEMONSTRATE OMS PROP FEED TO RCS.
CORRECTING ACTION:
USE MAN SW OVERRIDE IF CLOSURE DUE TO PREMAT SIG. X-FEED PROP CAN BE UTILIZED BY ONLY 2 OF 4 BANKS OF MANIFOLDED THRUSTERS.
REMARKS/HAZARDS:
NO HAZ IDEN FOR SINGLE VALVE FAILURE. FAILURE NOT EVID TILL VALVE ACTUATION REQ'D. PARAL FAILURE WOULD PREV OMS OR RCS X-FEED. [illegible]

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 83-2A -202111-2 REV:12/12/78
.ASSEMBLY :PROPELLANT FEED ABORT: ABORT, RTLS CRIT. FUNC: 2R
.P/N RI :MC284-0430-0007/-0008 CRIT. HDW: 3
.P/N VENDOR:5750025/5750026 MISSIONS: NF VF X FF OF SM
.QUANTITY :8 PHASE(S): PL LO X OO X OO X LS
. :TWO INTERCONNECT LINES
. :PER PROPELLANT TANK

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

.PREPARED BY: APPROVED BY: APPROVED BY (NASA):
.DES R GONZALEZ DES SSM
.REL C M AKERS REL REL

APPROVED WITH CHANGES
See Section 13.0

.ITEM: VALVE,
INTERCONNECT, 3 PHASE 400 HZ AC MOTOR OPERATED (115-200V), OMS/RCS (1 1/2").

.FUNCTION:
TO PROVIDE CONTROL OF INTERCONNECT LINE FOR VARIOUS MODES OF PROPELLANT FEED: 1) OPEN FOR OMS TO RCS 2) OPEN FOR RCS TO RCS 3) CLOSED FOR RCS TO SAME SIDE RCS AND OMS TO OMS. TWO INTERCONNECT VALVES PER PROP TANK ARE USED. EACH GOES INDEPENDENTLY TO SEPARATE MANIFOLD BANKS. LINE PRESSURE RELIEF TOWARDS PROP TANK IS PROVIDED.

.FAILURE MODE: FAILS CLOSED (F)
FAILS TO REMAIN OPEN.

.CAUSE(S):
VIB, LIMIT SW FAILURE, PREMATURE POWER TO MOTOR, ELECTRICAL SHORT RPC OPEN, JAMMING OF CAM.

.EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY. (B) DEGRADATION OF INTERFACE FUNCTION-CROSSFED PROP CAN BE UTILIZED BY ONLY 2 OF 4 MANIFOLD BANKS. (C) MISSION MODIFICATION-OPERATION CHANGES FOR ITEM 8 ABOVE. (D) NO EFFECT FOR OFT MISSIONS (LOSS OF THRUSTER MAY BE CRITICAL FOR RTLS IN SUBSEQUENT MISSIONS FOR OMS DEPLETION BURN). CRIT 1 FOR RTLS - LOSS OF 1 MANIFOLD FORWARD & 1 MANIFOLD AFT IS CRITICAL FOR ET SEPARATION & MATED COAST DURING RTLS. SINGLE COMPUTER FAILURE COULD RESULT IN THIS TYPE CONDITON. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE EARLY MISSION TERMINATION - INABILITY TO DEMONSTRATE OMS PROP FEED TO RCS.

.DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) AC MOTOR VALVE IS 3-PHASE - 2 OF 3 WINDINGS ARE ADEQUATE FOR VALVE FUNCTION. SERIES (HYBRID) RELAYS PROVIDE REDUNDANCY FOR THE PREMATURE CLOSE MODE. PARALLEL (HYBRID) RELAYS PROVIDE REDUNDANCY FOR ELECTRICAL POWER SIGNAL. ADDITIONALLY, REDUNDANT VALVES ARE PROVIDED. A 400-MICRON FILTER IS UTILIZED ON THE INLET AND OUTLET TO LIMIT THE POTENTIAL FOR CONTAMINATION CAUSED FAILURE OR JAMMING OF MOVING PARTS. (B) 2500 OPERATION CYCLES (OPEN-CLOSE-OPEN) AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITION. PROOF PRESSURE, LEAKAGE, OPERATION, CONDUCTED AS PART OF PRE/POST FLIGHT CHECKOUT. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED. CONTAMINATION CONTROL PROCESS, CORDS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS AND PROPER ELECTRICAL TERMINATIONS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO. 03-2A-202111-2 REV: 12/12/78
JULY 1976/CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND/FUNCTIONAL FLOW & LEAKAGE TESTS ARE MONITORED TO VERIFY THAT VALVES OPEN AND CLOSE PROPERLY UPON COMMAND. (D) NO PRIOR FAILURE HISTORY FOR THIS TYPE DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202120-3

ITEM Manifold Isolation Valve, A. C. FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [ ]	NO [X]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [X]	NO [ ]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

3. RCS RM automatically detects and prevents thrusting.

SHUTTLE FAILURE MODES AND EFFECTS ANALYSIS - [illegible]

SUBSYSTEM: [illegible] - REACTION CONTROL [illegible] [illegible]
.[illegible] : PROPELLANT F[illegible] ABORT: [illegible] [illegible]
.[illegible] : [illegible] 2[illegible]-[illegible] [illegible] [illegible] [illegible]
.[illegible] : [illegible] MISSIONS: [illegible]
.[illegible] : [illegible] PHASE(S): [illegible]
. [illegible] PRIMARY VALVE [illegible] NUMBER OF SUCCESS PATHS REMAINING
. [illegible] AFTER FIRST FAILURE:
. REDUNDANCY SCREENS: A-PASS [illegible]
.FAILURE [illegible] DETECTABLE IN FLIGHT?. YES [illegible]
.[illegible] AND [illegible] PRESS INDICATION. SECONDS
.[illegible] POSITION [illegible] REFERENCE [illegible]:
. MC 621-0029
.[illegible] TURNAROUND?..............YES MJ072-[illegible]
.[illegible] AS FLIGHT S072-[illegible]
. VS70-431[illegible]
.
.
.
. PREPARED BY: APPROVED BY:
. DES R. GONZALEZ DES ______________________
. REL C. [illegible]AKERS REL ______________________
.
.
.ITEM: VALVE
. MANIFOLD ISOLATION. 3 PHASE AC MOTOR OPERATED ([illegible]) ([illegible]).
 [illegible]
.FUNCTION:
. [illegible] PROPELLANTS PRIOR TO SYSTEM ACTIVATION. [illegible]
 [illegible]) TO ISOLATE A FAILED OPEN THRUSTER OR DOWNSTREAM LEAK. EACH
 MANIFOLD ISOLATION VALVE CONTROLS 3 PRIMARY THRUSTERS. [illegible]
 RELIEF TOWARDS FROM TANK IS PROVIDED.
.FAILURE MODE: FAILS CLOSED-PREMATURE (F)
. [illegible], FAILS TO REMAIN OPEN.
.CAUSE(S):
. [illegible], LIMIT SWITCH MALFUNCTION, PREMATURE POWER TO MOTOR.
 PREMATURE MOTOR SIGNAL. RPC SHORT.
.EFFECT(S): [illegible] (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A)(B) LOSS OF REDUNDANCY-LOSS OF PROP FLOW & USE OF [illegible] PRIMARY
. THRUSTERS ([illegible] MANIFOLDS). (C)(D) NO EFFECT FOR SINGLE FAILURE FOR
 [illegible] MISSIONS (LOSS OF THRUSTER MAY BE CRITICAL FOR RTLS [illegible]
 [illegible] [illegible] I FOR RTLS - LOSS OF [illegible] MANIFOLD.
 [illegible] MANIFOLD [illegible] IS CRITICAL FOR ET SEPARATION [illegible]
 [illegible] [illegible]. SINGLE COMPUTER FAILURE COULD RESULT IN THIS TYPE
 CONDITION. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE
 LOSS DUE TO INABILITY TO USE RCS IF ALL MANIFOLD VALVES FAIL CLOSED.
.CORRECTING ACTION:
. UTILIZE REMAINING THRUSTERS FOR FUNCTION. ATTEMPT TO REOPEN CLOSED
 VALVE BY USE OF MANUAL SW.
.REMARKS/HAZARDS:
. [illegible] PARK[illegible] PNLA # RPK [illegible]. NO HAZARDS IDENTIFIED FOR NORMAL
 MISSION. LANDING HAZ, AERODYNAMIC CONTROL, TOXIC, FIRE & EXPLOSION IF
 GAS/RCS PROP NOT DEPLETED PRIOR TO LANDING (RTLS). VALVES ARE NORMALLY
 OPEN ~~AND~~ PREMATURE CLOSE SIGNAL DURING LAUNCH PHASE (RTLS) IS CONSIDERED

[illegible]

[illegible]

SUBSYSTEM :AFT - REACTION CONTROL — FMEA NO 03-2A -202120-3 . REV:12/12/73
•ASSEMBLY :PROPELLANT FEED — ABORT: ABCPT, RTLS — CRIT. FUNC: 1R
•P/N RI :MC 284-0430-0001/-0002 — CRIT. HDW: 3
•P/N VENDOR:5750023/5750024 — MISSIONS: HF VF X FF OF SM
•QUANTITY :16 — PHASE(S): PL LO X OO X DO X LS
• :FOUR PRIMARY VALVE MANI-
• :FOLDS PER PROP

REDUNDANCY SCREEN: A-PASS B-PASS C-PASS

•PREPARED BY: R.GONZALEZ
•DES
•REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY (NASA):
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

•ITEM: VALVE
•MANIFOLD ISOLATION, 3 PHASE, 400 HZ AC MOTOR OPERATED (115-200V) (1 1/2" INLET, 1 1/4" OUTLET).
•FUNCTION:
• 1) TO ISOLATE THRUSTERS FROM PROPELLANTS PRIOR TO SYSTEM ACTIVATION AND 2) TO ISOLATE A FAILED OPEN THRUSTER OR DOWNSTREAM LEAK. EACH MANIFOLD ISOLATION VALVE CONTROLS 3 PRIMARY THRUSTERS. LINE PRESSURE RELIEF TOWARDS PROP TANK IS PROVIDED.
•FAILURE MODE: FAILS CLOSED-PREMATURE (F)
• OPERATION, FAILS TO REMAIN OPEN.
•CAUSE(S):
• VIBRATION, LIMIT SWITCH MALFUNCTION, PREMATURE POWER TO MOTOR, PREMATURE MOTOR SIGNAL, P/C SHORT.
•EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
• (A)(B) LOSS OF REDUNDANCY-LOSS OF PROP FLOW & USE OF 3 PRIMARY THRUSTERS (1 OF 4 MANIFOLDS). (C)(D) NO EFFECT FOR SINGLE FAILURE FOR OFT MISSIONS (LOSS OF THRUSTER MAY BE CRITICAL FOR RTLS IN SUBSEQUENT MISSIONS FOR OMS DEPLETION BURN). CRIT 1 FOR RTLS - LOSS OF 1 MANIFOLD FORWARD & 1 MANIFOLDAFT IS CRITICAL FOR ET SEPARATION & MATED COAST DURING RTLS. SINGLE COMPUTER FAILURE COULD RESULT IN THIS TYPE CONDITION. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE CREW/VEHICLE LOSS DUE TO INABILITY TO USE RCS IF ALL MANIFOLD VALVES FAIL CLOSED.
•DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
• (A) AC MOTOR VALVE IS 3-PHASE - 2 OF 3 WINDINGS ARE ADEQUATE FOR VALVE FUNCTION. SERIES (HYBRID) RELAYS PROVIDE REDUNDANCY FOR THE PREMATURE CLOSE MODE. PARALLEL (HYBRID) RELAYS PROVIDE REDUNDANCY FOR ELECTRICAL POWER SIGNAL. ADDITIONALLY, REDUNDANT VALVES ARE PROVIDED. A 400-MICRON FILTER IS UTILIZED ON THE INLET AND OUTLET TO LIMIT THE POTENTIAL FOR CONTAMINATION CAUSED FAILURE OR JAMMING OF MOVING PARTS. (B) 2500 OPERATION CYCLES (OPEN-CLOSE-OPEN) AND RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS ARE PERFORMED DURING QUAL. ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITION. PROOF PRESSURE, LEAKAGE, OPERATION, CONDUCTED AS PART OF PRE/POST FLIGHT CHECKOUT. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED. CONTAMINATION CONTROL PROCESS, CORDS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS AND PROPER ELECTRICAL TERMINATIONS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED JULY 1976/CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO. 03-2A-202120-3 REV: 12/12/78
TO CONTRACT REQMTS. TURNAOUND/FUNCTIONAL FLOW & LEAKAGE TESTS ARE MONITORED
TO VERIFY THAT VALVES OPEN AND CLOSE PROPERLY UPON COMMAND. (D) NO PRIOR
FAILURE HISTORY FOR THIS TYPE DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202140-1

ITEM Manifold Isolation Valve, D.C. FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES ☐	NO ☒
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES ☐	NO ☐
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES ☒	*NO ☐
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES ☒	NO ☐
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES ☐	NO ☐
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES ☐	NO ☒
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES ☐	NO ☒
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 ☒	*1 ☐ 2 ☐
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A ☐	YES ☒ NO ☐
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES ☒	*NO ☐
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES ☐	*NO ☒

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. ☐ NO H/S ISSUES	3. ☐ NO SOFTWARE DETECTION	5. ☐ ACCEPTANCE RATIONALE BELOW
2. ☐ HARDWARE ACCEPTS RISK	4. ☒ DETECTION DURING CHECKOUT	6. ☐ RECOMMENDED CHANGES BELOW

☐ FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

3. The RCS Redundancy Management software will inhibit the firing of those jets associated with the failed valve.

6. There are no success paths remaining after first failure.

8B. Same as primary.

[illegible] FILE FAILURE MODE AND EFFECTS ANALYSIS — [illegible]

SUBSYSTEM: [illegible] — REACTION CONTROL   FMEA NO 03-2A -2[illegible]-1   [illegible]
ASSEMBLY: PROPELLANT FEED   ABORT: CRIT. HDW: [illegible]
P/N RI: [illegible]   CRIT. FUNC: [illegible]
P/N VENDOR: [illegible]   MISSIONS: [illegible]
QUANTITY: [illegible]   PHASE(S): PL LO [illegible] LS
[illegible]   NUMBER OF SUCCESS PATHS REMAINING
:   AFTER FIRST FAILURE: [illegible]
REDUNDANCY SCREENS: A-PASS B-PASS C-P[illegible]

[illegible] DETECTABLE IN FLIGHT? YES
[illegible] POSITION INDICATOR FOR V42X-[illegible]34X, [illegible]34X, [illegible]

GROUND TURNAROUND?...............YES
SAME AS FLIGHT, VISUAL INSPECTION

TIME TO EFFECT: [illegible]

REFERENCE DOCUMENTS:
MC 521-[illegible]
[illegible]70-[illegible]
SD72-SH-[illegible]
VS70-[illegible]1[illegible]01

PREPARED BY:
DES   R. BURKHART
REL   C M AKERS

APPROVED BY:
DES ____________________
REL ____________________

[illegible] : VALVE,
[illegible] ISOLATION, VERNIER THRUSTER, SOLENOID ([illegible]VDC) [illegible]
(LATCHING) LV 2[illegible]/2[illegible]7/ [illegible]/3[illegible]8.
FUNCTION:
[illegible] PROVIDE VERNIER THRUSTER ISOLATION: 1) PRIOR TO SYSTEM ACTIVATION AND 2) IN THE EVENT OF A RUNAWAY THRUSTER OR MANIFOLD LEAK.
FAILURE MODE: FAILS CLOSED. (F)

CAUSE(S):
INADVERTENT ELECTRICAL SIGNAL (CONTINUOUS SHORT) [illegible] LOW MAGNETIC FORCE [illegible] LATCHING MAGNET, MECH SHOCK, VIB., CONTAM (AIN [illegible]).
EFFECT(S) ON: (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION (VERNIER THRUSTER). (B) DEGRADATION OF INTERFACE SUBSYSTEM-PAYLOAD MANIPULATION. (C) MISSION MODIFICATION OR ABORT DECISION. (D) NO EFFECT UNLESS ADDITIONAL FAILURES OCCUR.
CORRECTING ACTION:
UTILIZE FORWARD RCS VERNIER. ATTEMPT TO REOPEN MANIFOLD ISOL VALVE BY USE OF MANUAL SW.
[illegible]S/HAZARDS:
POTENTIAL FOR COLLISION WITH/OR LOSS OF PAYLOAD/SATELLITE. DUAL SWITCHING WILL PRECLUDE INADVERTENT ACTUATION. SEE CONSOLIDATED CONTROLS FMEA # 7[illegible]295 FMEA 1. REF HAZ NO 1YXX-[illegible]. [illegible] TO USE OF FWD RCS VERNIER & FREE DRIFT AS BACK-UP MODES DELETED AT NASA REQUEST.

ORIGINAL PAGE IS OF POOR QUALITY

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :PROPELLANT FEED
P/N RI :MC234-0420-0011/-0012
P/N VENDOR:73895
QUANTITY :4
:TWO PER MODULE
:

FMEA MC 03-2A -202140-1 REV:12/12/7?
ABORT:
~~CRIT. FC NO:~~ 2
CRIT. HDW: 2
MISSIONS: HF VF X FF DF SM
PHASE(S): PL LO CC X DO LS

REDUNDANCY SCREEN: A-PASS B-PASS C-FAIL

PREPARED BY:
DES R. BURKHART
REL C M AKERS

APPROVED BY:
DES M W Fisher
REL C. E Jarnes 12/17?

APPROVED BY (NASA):
SSM W. Kaschube
RE Bernhard

APPROVED WITH CHANGES
See Section 13.0

ITEM: VALVE.
MANIFOLD ISOLATION, VERNIER THRUSTER, SOLENOID (28VDC) BI-STABLE (LATCHING) LV 258/257/357/358.

FUNCTION:
TO PROVIDE VERNIER THRUSTER ISOLATION: 1) PRIOR TO SYSTEM ACTIVATION AND 2) IN THE EVENT OF A RUNAWAY THRUSTER OR MANIFOLD LEAK.

FAILURE MODE: FAILS CLOSED. (F)

CAUSE(S):
IMPROPER ELECTRICAL SIGNAL (CONTINUOUS SHORT) OR LOW MAGNETIC FORCE FROM LATCHING MAGNET, MECH SHOCK, VIB., CONTAM (AIR GAP).

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION (VERNIER THRUSTER). (B) DEGRADATION OF INTERFACE SUBSYSTEM-PAYLOAD MANIPULATION. (C) MISSION MODIFICATION OR ABORT DECISION. (D) NO EFFECT UNLESS ADDITIONAL FAILURES OCCUR.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) SERIES SWITCHES (RPC'S) MINIMIZE POTENT FOR INADVER ACTUATION. PARAL SWITCHES (RPC'S) PROVIDE ELECT REDUN FOR THE OPENING SIG. AN INDUCT VOLTAGE SUPRES CIRCUIT IS PROV IN THE ELECTRICAL SYSTEM TO PREV DAMAGE TO OTHER ON-LINE COMP. REDUNDANT DIODES LIMIT THE POSS OF DIODE FAILURE ALLOWING CURRENT SHUNT FROM THE COIL.

: 100 MICRON FILTER IS PROV TO LIMIT THE POSS OF CONTAM CAUSING JAMMING MOVING PARTS. TO LIMIT THE ELECT SHORT POTENT, THE LEAD AND MAGNET WIRES ARE ENCAP BY POTTING AND A FIXTURE IS USED DURING ASSEMBLY TO ENSURE THAT INSUL IS NOT DAMAGED BY THE EXIT NOTCH WHEN THE COIL SLEEVE IS PRESSED ONTO THE COIL. (B) 2000 CYCLES (ON-OFF-FLOW) AND RANDOM VIB AT ANTIC MISSION LEVELS ARE PERF DURING QAL. ITEM IS USED DURING SYS EVAL TESTS AT WSTF ALLOWING EVAL UNDER SIMUL MISSION USAGE COND. PROOF PRESS, LEAKAGE, OPER AND INSUL TESTS ARE PERF DURING ATP. APPROP LOCATED TEST POINTS ALLOW PRE/POST FLIGHT LEAKAGE TESTS AND OPER TESTS ARE ALSO COND AT THIS TIME. (C) AND IDENTIF IS PERF AND THE UNIT TAGGED. CONTAM CONT PROCESS, CORROS. PROT PROV, NDE EXAM. OF WELDS AND BRAZES, INSP. FOR SURFACE AND SUBSURFACE DEFECTS AND PROPER ELECT TERMINATIONS ARE VERIF BY INSPECT. THE FOLL ITEMS ARE VERIF BY SHOP TRAVELER INSP. POINTS- RAW MAT'L (LOT CERTIF), PARTS PROT, MANUF., COATING, PLATING, INSTALL AND ASSY OPER. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT COND

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202140-1 REV:12/12/78
8-31-77. CONTAM CONT PROC, CORROS. PROT PROV TURNAROUND- FUNCT FLOW
TESTS ARE MONIT TO VERIFY THAT VALVES OPEN AND CLOSE PROPERLY UPON
COMMAND. (D) APOLLO FAILURES WERE MAINLY ASSOC WITH REVERSE POLARITY
AND DEGUASSING OF MAGNETS. THE SHUTTLE VALVE UTILIZES A CONNECTOR
(RATHER THAN LEAD WIRES) AND A BLOCKING DIODE WHICH PREVENTS THIS TYPE
OF ERROR DURING CONN. DEVEL TEST AND ANAL SHOWED PRESS SURGE FATIGUE
PROBLEM. THIS IS BEING RESOLVED BY REDUCING THE LIFE OF THE VALVE TO 50
MISSIONS.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-202150-1

ITEM Propellant Fill & Bleed Disconnect FAILURE MODE Fails Open

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ] *NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In FTight Detectability
[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection will give first indication.

6. There is one success path remaining after the first failure.

8B. Same as primary.

2. Measurements V42P2313C, 2315C, 2313C and 3315C are not listed in the MML.

[illegible] FAILURE MODE AND EFFECTS ANALYSIS - [illegible]

[illegible] SYSTEM :RCS - REACTION CONTROL [illegible]
[illegible]ASSEMBLY :RCS PROPELLANT ANALYST: [illegible]
[illegible] :MA-7A-.1 [illegible]
[illegible]: [illegible] TANK ASSY [illegible]
FACILITY :KSC [illegible]
:VEHICLE [illegible]
: [illegible]

CRITICALITY CODES: [illegible]

FAILURE SAFETY CRITICALITY: Y,S [illegible]
CAUSE OF TANK PRESSURE VAPOR-[illegible]
[illegible]

[illegible] TURNAROUND?.....N/A

[illegible]
MS421-[illegible]
MS370-[illegible]
SS72-[illegible]
VS70-[illegible]

PREPARED BY: APPROVED BY:
DES C SCARLETT QES _____
REL C MARKERS QCL _____

[illegible]: DIAPHRAGM/DIAL [illegible]
PROPELLANT, SPRING LOADED PUSHER WITH STRUCTURAL CAP (1/AP [illegible] 1/CP).
[illegible]:
TO PROVIDE FOR VENTING AND BLEEDING PROPELLANT TANKS DURING SERVICING OF VEHICLE [illegible] VEHICLE OPERATION. USE INDICATES PROPELLANT [illegible] SERVICES ARCS AND GAS. ITEM INCORPORATES SECONDARY INTERNAL SEALS AND HAS A PRESSURE CAP WHICH IS REDUNDANT SEAL. [illegible] INSTALL 3 MILK TO [illegible].
FAILURE MODE: FAILS OPEN. (S)
CAP LEAKS IN EXCESS OF ACCEPTABLE RATE, SEALS DAMAGE [illegible] OF LEAKS EXCEEDING CAP SEAL REDUNDANCY.
CAUSE(S):
VIBRATION, PIECE PART STRUCTURAL FAILURE, MECHANICAL SHOCK DURING, [illegible] TO [illegible], SEAL DAMAGE, NO LINE SUPPORT-SMART OR CONE [illegible] MAINT OF USE HALF.
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF SUBSYSTEM PROPELLANT. (B) DEGRADATION OF INTERFACE SUBSYSTEM (PROPELLANT LOSS). (C) LAUNCH DELAY OR [illegible]. (D) POTENTIAL CREW LOSS DURING MISSION IF PROPELLANT OF [illegible] POTENTIAL.
CORRECTING ACTION:
REPLACE COMPONENT IF PRIOR TO LAUNCH, ATTEMPT TO ISOLATE LEAK. EVALUATE NECESSITY FOR ABORT.
REMARKS/HAZARDS:
POTENTIAL CORROSIVE, TOXIC, FIRE OR EXPLOSIVE HAZARD [illegible] HIGH TEMPERATURE OF REACTANTS ARE PRESENT. REF HAZ 1YXX-03-2-15, NO.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :PROPELLANT
P/N RI :MC276-0018
P/N VENDOR:76301000 & 76306000
QUANTITY :12
:VEHICLE
:6/POD
2 OF 1/2 IN.
4 OF 1/4 IN.

FMEA NO 03-2A -202150-1 REV:11/03/78
ABORT: CRIT. FUNC: 1
CRIT. HDW: 1
MISSIONS: NF VF X FF OF SM
PHASE(S): PL LO X CO X DO X LS

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES C SCARLETT
REL C M AKERS

APPROVED BY:
DES C. Scarlett 12/15/78
REL C. E. Jones 12/15/78

APPROVED BY (NASA):
SSM W. Kemlick
REL T. Karlovich
APPROVED WITH CHANGES
See Section 13.0

ITEM: DISCONNECT,FILL & BLEED
PROPELLANT, SPRING LOADED POPPET WITH STRUCTURAL CAP(1/4" & 1/2").

FUNCTION:
TO PROVIDE FOR VENTING AND BLEEDING PROPELLANT TANKS DURING SERVICING IN VERTICAL VEHICLE ORIENTATION. ONE INCH COUPLING, (FUEL-LEFT POD AND OX-RIGHT POD) SERVICES APCS AND OMS. ITEM INCORPORATES SECONDARY INTERNAL SEALS AND HAS A PRESSURE CAP WHICH IS REDUNDANT SEAL. CAP INSTALLED PRIOR TO FLIGHT.

FAILURE MODE: FAILS OPEN. (S)
CAP LEAKS IN EXCESS OF ACCEPTABLE RATE, SEALS DAMAGED RETAINING NUT LOOSENS NEGATING CAP SEAL REDUNDANCY.

CAUSE(S):
VIBRATION, PIECE PART STRUCTURAL FAILURE, MECHANICAL SHOCK CONTAM, EXCESS TORQUE, SEAL DAMAGE, NO LINE SUPPORT-SHAFT OR CORE DENT, INADEQ MAINT OF GSE HALF.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF SUBSYSTEM PROPELLANT. (B) DEGRADATION OF INTERFACE SUBSYSTEM (PROPELLANT EFFECTS). (C) LAUNCH DELAY OR ABORT DECISION. (D) POTENTIAL CREW LOSS DURING MISSION IF PROPELLANT CANNOT BE UTILIZED OR DEPLETED.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) F.S. IS 2.0 X WORKING PRESS. GROUND HALF COUPLINGS AND LINES ARE ADEQ SUPPORTED TO LIMIT ANY UNDUE STRESS ON THE COUPLING DURING SERVICE AND PREV DAMAGE TO SEALS. A SAFETY FEATURE PRIOR TO REMOVAL OF THE END CAP IS A PROV WHEREBY ANY LEAKAGE PAST THE AIRBORNE POPPET SEAL CAN BE VENTED OVERBOARD BY ROTATING A BLEED SCREW. COMPLETE STRESS ANAL HAS BEEN CONDUCTED. UTIL OF STRUCT CAP MINIMIZES LEAKAGE POTENTIAL AND PROVIDES A REDUNDANT SEAL EXCEPT FOR STRUCT FAILURE. (B) THE COUPLING IS SUBJECT TO 600 OPER CYCLES (COUPLING AND UNCOUPLING) DURING QUAL IN ADDITION TO PRESS SURGE CYCLING AND PROP EXPOSURE TESTS. RANDOM VIB TESTING IS ALSO CONDUCTED AT ANTIC VEH LEVELS FOR 34 MINUTES IN EACH AXIS. USAGE DURING SYS EVAL TESTS AT WSTF ALLOWS EVAL UNDER ACTUAL USAGE COND. PROOF PRESS TESTS ARE CONDUCTED DURING ATP & LEAKAGE TESTS ARE PERF BEFORE & AFTER OPER CYCLES. (C) AN IDENT IS PERF. RAW MAT'L NDE EXAM, VISUAL INSP FOR SURFACE DEFECTS, & EQUIP CONFORMANCE TO CONTRACT REQMTS ARE VERIF BY RECEIVING INSP. MEASUREMENT STANDARDS & TEST EQUIP. STANDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPECS. THE FOLLOWING ITEMS ARE VERIF BY SHOP TRAVELER MANDATORY INSP POINTS-PARTS.

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -202150-1 REV:11/08/7[illegible]
PROT, MFG. PROCESSES, COATING, ASSY AND INSTALLATION. THE ABOVE ITEMS & THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 5-23-77. CORROS PROT PROV, CONTAM CONT PROCESSES, TEST HANDLING, & STORAGE ENVIR. THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT OF MARCH 6, 1978. INSPECTION VERIFIES ASSEMBLY PER INSPECTION POINTS IN MASTER RECORD. LOG OF CLEAN ROOM AND CALIBRATION OF TOOLS VERIFIED. CRITICAL DIMENSION 100% VERIFIED BY INSPECTION. PARTS CLEANLINESS AND PASSIVATION BY INSPECTION. NDE INSPECTION PERFORMED AFTER ASSEMBLY. TURNAROUND-COUPLINGS ARE VISUALLY INSP FOR EVID OF DAMAGE SEALS & LEAK TESTS ARE PERFORMED. (D) APOLLO FAILURE HISTORY WAS IN THE MAIN ASSOC WITH GROUND USAGE, IMPROPER HANDLING.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-211110-1

ITEM Propellant Tank Assy. FAILURE MODE External Leak

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X]	*1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ]	*NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES	3. [ ] NO SOFTWARE DETECTION	5. [ ] ACCEPTANCE RATIONALE BELOW
2. [X] HARDWARE ACCEPTS RISK	4. [ ] DETECTION DURING CHECKOUT	6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection gives first indication.

6. Pod redundancy.

8B. Backup flight system same as primary.

[illegible]

PHASE(S): [illegible]

[illegible]

PREPARED BY:
DLS
PEL

APPROVED BY:
DES _____
PEL _____

ITEM: TANK ASSY, PROPELLANT

FUNCTION:
TO STORE AND SUPPLY PROPELLANT FOR REACTION CONTROL PROPULSION. ALSO UTILIZED TO SERVICE VARIOUS PROPELLANTS PER ALLOCATE FUND DURING [illegible] MET CONDITIONS. REGULATED HELIUM IS SUPPLIED TO THE ULLAGE TO FORCE PROPELLANT TO THE [illegible] AND MEOH (4.04 -1b) IS SAFELY RETAINED (17.95 CUBIC FEET).

FAILURE MODE: STRUCTURAL FAILURE (F)

EXTERNAL LEAK, TANK WALL CRACK OR SEAL FAILURE.

CAUSE(S):

METEOROID SHOCK, FATIGUE/VIB, OVERPRESS, STRESS CORROS, IMPROPER PROPELLANT ON TEST FLTS, OVER TEMP, PLUME OR REENTRY GASES, STRESS RISER, FIELD OF MATL DEFECT, INCORRECT OR DAMAGED SEAL.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:

(A) LOSS OR DEGRADATION OF SUB-SYSTEM DEPENDENT ON EXTENT OF FAILURE.
(B) LOSS OR DEGRADATION OF INTERFACE SUBSYSTEM-APU'S, PU'S, [illegible] WITH TANK. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE (EXPLOSION, LACK OF PROPELLANT OR INABILITY TO DUPLATE OPPOSITE PROPELLANT).

CORRECTING ACTION:

NOTHING AFTER LAUNCH WOULD TEND TO BE CATASTROPHIC. CLOSE HELIUM AND TANK ISOLATION VALVE AS APPROPRIATE EVAL SITUATION & EXTENT OF DAMAGE. INITIATE ABORT OR RESCUE.

REMARKS/HAZARDS:

PRESSURIZATION OF PROP TANKS AND DAMAGE TO PUB & TPS RESULTING IN FIRE OR EXPLOSION TOXIC, CORROS, FIRE & HAZARD TO GND CREW & VEH. ITEM IS FOUND NOT FOUND FOR THIS FAILURE MODE. REFERENCE HAZARDS 1YXX-C10L-01, 1YXX-[illegible]-04 AND 1YXX-USC2-05.

C-2

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :PROPELLANT FEED
P/N RI :MC282-0061-0001,-0002
P/N VENDOR:355C3310000-010,-020
QUANTITY :4
:TWO PER
:MODULE

FMEA NO 03-2A -211110-1 REV:11/08/78
ABORT: CRIT. FUNC: 1
CRIT. HDW: 1
MISSIONS: PF VF X FF DF SM
PHASE(S): PL X LO X OO X DO X LS

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES R BEMIS
REL C M AKERS

APPROVED BY:
DES R Bemis
REL C. E. Jarmel 1979

APPROVED BY (NASA):
SSM W. Lee Lueb
REL for T. Tara Smith

APPROVED WITH CHANGES
See Section 13.0

ITEM: TANK ASSY, PROPELLANT
INCLUDING ACQUISITION DEVICE AND RETENTION SCREENS (1.5 FACTOR OF SAFETY) TK 203/204/303/304.

FUNCTION:
TO STORE/SUPPLY PROPELLANT FOR REACTION CONTROL THRUSTERS. TANK SHELL CONTAINS PROPELLANT AND ACQUISITION DEVICE RETAINS PROPELLANTS FOR ADEQUATE FEED DURING 1"G", 0"G" AND HIGH "G" CONDITIONS. REGULATED HELIUM IS SUPPLIED TO THE ULLAGE TO FORCE PROPELLANT TO THE THRUSTERS AS REQ'D. 245 PSIA (+ OR -15) (17.95 CUBIC FEET).

FAILURE MODE: STRUCTURAL FAILURE (F)
EXTERNAL LEAK, TANK WALL CRACK OR SEAL FAILURE.

CAUSE(S):
MECH SHOCK, FATIGUE/VIB, OVERPRESS, STRESS CORROS, IMPROPER PROP PURITY OR TEST FLUID, OVER TEMP, PLUME OR REENTRY GASES, STRESS RISER, WELD OR MAT'L DEFECT, INCORRECT OR DAMAGED SEAL.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OR DEGRADATION OF SUB-SYSTEM DEPENDENT ON EXTENT OF FAILURE. (B) LOSS OR DEGRADATION OF INTERFACE SUB-SYSTEM-AFT RCS, POD, TPS OR VEH DAMAGE. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE (EXPLOSION, LACK OF PROPELLANT OR INABILITY TO DEPLETE OPPOSITE PROPELLANT).

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) THE F.S. (BURST) IS 1.5 X WORKING PRESSURE. COMPLETE STRESS ANALYSIS FOR EACH TANK SEGMENT WAS PERFORMED. TANK IS CLASSIFIED AS FRACTURE CRITICAL FOR HANDLING AND IS SUBJECT TO FRACTURE CONTROL REQMTS. ALL FITTINGS AND FLANGES USED ON THE TANK HAVE DUAL ELASTOMER SPRING LOADED SEALS. (B) QUAL REQUIRES 800 PRESSURE WITH (INCLUDING 200 EXPULSION CYCLES AND A 90 DAY CREEP AND PROPELLANT EXPOSURE TEST. PROOF PRESSURE (1.3X WORKING PRESSURE) AND LEAKAGE TESTS ARE PERFORMED DURING ATP- RADIOGRAPHIC AND DYE PENETRANT TESTS ARE PERFORMED TO VERIFY NO PERMANENT DEFORMATION OR FLAW GROWTH. WELDS ARE VISUALLY INSPECTED FOR EVIDENCE OF STRESS RISER OR OTHER FLAWS. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. RAW MAT'L AND PURCHASED COMPONENT REQMTS ARE VERIFIED BY RECEIVING INSP. MEASUREMENT STANDARDS AND TEST EQUIP. STANDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPECS. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSPECTION POINTS- PARTS PROTECTION, MFG. PROCESSES, FINISHES, ASSY AND INSTALLATION. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -211110-1 REV:11/03/78
AUDIT CONDUCTED 11-1-76. CORROSION PROTECTION PROVISIONS, TEST HANDLING, AND STORAGE ENVIRONMENTS. TENSILE, HEAT TREAT AND WELD SAMPLES ARE TESTED DURING IN-PROCESS FABRICATION IN ADDITION TO X-RAY AND DYE PENTRANT INSPECTION FOR SURFACE AND SUBSURFACE DEFECTS. BOTH CERTIFIED WELDERS AND CERTIFIED INSPECTORS ARE USED FOR ALL WELDS. TURNAROUND- INSPECTION TO MONITOR FUNCTIONAL TEST DURING PRESSURIZATION CYCLE FOR EVIDENCE OF LEAKS. LEAKAGE TESTS ARE PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND PERIODICALLY AS PART OF CHECK-OUT PROCEDURE PRIOR TO FLIGHT. PRESSURE CYCLES ACCUMULATED ARE ALSO RECORDED. (0) APOLLO FAILURES WERE ASSOC. WITH INCORRECT TEST FLUID (METHYL ALCOHOL), IMPROPER PROPELLANT NO CONTENT, STRESS RISER OR TEST ERROR RESULTING IN CREATION OF VACUUM. CORRECTIVE ACTION WAS TAKEN FOR ALL OF ABOVE FAILURES AND ALSO IMPLEMENTED ON SHUTTLE.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-211110-2

ITEM Propellant Tank Assy FAILURE MODE Bubbles in Propellant

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [X]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ]	*NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed off" thruster may illuminate if < 40 psi is sensed 3 times 80 milliseconds apart.

5. Crossfeed.

8b. Same as primary.

SYSTEM: ENTRY - REACTION CONTROL
SUBSYSTEM: PROPELLANT
ASSY:
MISSIONS:
PHASE(S):
NUMBER OF SUCCESS PATHS REMAINING:
AFTER FIRST FAILURE:
REDUNDANCY SCREENS:
CRITICALITY:
FAILURE DETECTABLE IN FLIGHT: YES
TIME TO EFFECT:
CREW TRANSITIONAL PERFORMANCE THRU CHAMBER PRESSU
REMARKS:
FAILURE ISOLATION:
NO GROUND RULES APPLIED
MSFC-SPEC-
SSTC-SPEC-
VSTC-

PREPARED BY: R BENIS
PIL C W AKERS
APPROVED BY:
QPA _____
MGR _____

ITEM: TANK ASSY, PROPELLANT
FUNCTION: PROVIDES PROPELLANT ACQUISITION DEVICE AND RETENTION SCREENS (1.3 FACTOR OF SAFETY) TO 200/204/300/204.
MODE(S):
1. SUPPLY/SUPPLY PROPELLANT FOR REACTION CONTROL THRUSTERS. ACQUISITION DEVICE PROVIDES PROPELLANTS AT ADEQUATE FLOW RATES AND PRESSURES. RETENTION SCREEN IS SUPPLIED TO TANK OUTLET TO PREVENT PROPELLANT TO THE THRUSTERS AS NEEDED. 240 PSIA (+ OR -10) 1.3 SAFETY FACTOR (17.5 CUBIC FEET).
FAILURE MODE: STRUCTURAL FAILURE (S)
1. FAILS TO FEED PROPELLANT DUE TO RETENTION DEVICE FAILURE, GAS PUMPED TO THRUSTER.
CAUSE(S):
1. FATIGUE, STRESS CORROS, CORROS, VIB, MECH SHOCK, SCREEN COLLAPSE, WELDING PROB, PROP SLOSH LOADS, FASTENING BOARD FAILS
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A,B) SUBSYSTEM AND INTERFACE DEGRADATION - GAS PUMPED TO THRUSTER CAUSES FAILED OPEN OR CLOSED THRUSTER. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW VEHICLE - NASA STATS FAILURE OF PROPULSION SYSTEM WILL EFFECT MISSION AND CONTAMINANT PROPELLANT & PREVENT USE OF SUBSYSTEM E.G. CONT. PROP. FOR ENTRY CONTROL.
CORRECTIVE ACTION:
CANCEL/ABORT VEHICLE TO TRY TO RE-ORIENT PROPELLANT IN OUTLET.
REMARKS/HAZARDS:
POTENTIAL HAZARD IF FAILURE OCCURS DURING CRITICAL MISSION PHASES. POSSIBLE LOSS OF THRUSTER DUE TO EXCESSIVE HELIUM GUMMING. CROSS CONTAMINATE, CAUSING CHAMB. EXPLOSION. REF. HAZ. NO. EYKA-0002-02. ITEM CHANGED FROM CRITICALITY 2 TO CRITICALITY 1 PER NASA REQUEST.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :PROPELLANT FEED
P/N RI :MC292-0061-0001,-0002
P/N VENDOR:85503310000-010,-020
QUANTITY :4
:TWO PER
:MODULE

FMEA NO 03-24-211110-2 REV:12/13/78
ABORT: CRIT. FUNC:. 1
CRIT. HDW: 1
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO X OO X DO LS

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES R BEMIS
REL C M AKERS

APPROVED BY:
DES R Bemis 12/7/78
REL C E James 12/7/78

APPROVED BY NASA:
SSM, W. Hamilton
REL J A Tom Smith
APPROVED WITH CHANGES
See Section 13.0

ITEM: TANK ASSY, PROPELLANT
INCLUDING ACQUISITION DEVICE AND RETENTION SCREENS (1.5 FACTOR OF SAFETY) TK 203/204/303/304.

FUNCTION:
TO STORE/SUPPLY PROPELLANT FOR REACTION CONTROL THRUSTERS. ACQUISITION DEVICE RETAINS PROPELLANTS FOR ADEQUATE FEED DURING 1"G", 0"G" AND HIGH "G" CONDITIONS. REGULATED HELIUM IS SUPPLIED TO THE ULLAGE TO FORCE PROPELLANT TO THE THRUSTERS AS REQ'D. 245 PSIA (+ OR -15) (17.95 CUBIC FEET).

FAILURE MODE: STRUCTURAL FAILURE (S)
FAILS TO FEED PROPELLANT DUE TO RETENTION DEVICE FAILURE, GAS BUBBLES IN PROPELLANT.

CAUSE(S):
FATIGUE, STRESS CORROS, CONTAM, VIB, MECH SHOCK, SCREEN COLLAPSE, FROZEN PROP, PROP SLOSH LOADS, FASTENING HDWRE FAILS

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A,B) SUBSYSTEM AND INTERFACE DEGRADATION - GAS BUBBLES IN PROP CAUSING REDUCED THRUST OR COMB INSTAB. (C) ABORT DECISION. (D) POSSIBLE LOSS OF CREW VEHICLE - NASA STATES FAILURE OF ACQUISITION DEVICE SCREENS COULD CAUSE PREMATURE GAS INJECTION INTO THE THRUSTER MANIFOLDS DURING ENTRY MANEUVERING.

DISPOSITION & RATIONALE (A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY:
(A) SAFETY FACTORS OF 1.5 (MINIMUM) IN SCREEN WILL MINIMIZE FAILURE POTENTIAL. (B) QUAL REQUIRES 200 EXPULSION CYCLES A 90 DAY PROPELLANT EXPOSURE TEST. DEVELOPMENT CERTIFICATION TESTS DEMONSTRATE 100 MISSION FLOW TRANSIENTS (188,800 CYCLES) AND TWO YEAR PROPELLANT COMPATIBILITY. PROPELLANT ACQUISITION DEVICE AND WELD INTEGRITY VERIFIED VIA BUBBLE POINT TESTS AT THE COMPONENT, SUBASSEMBLY & TANK ASSY LEVEL. (C) AN IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. RAW MAT'L AND PURCHASED COMPONENT REQMTS ARE VERIFIED BY RECEIVING INSP. MEASUREMENT STANDARDS & TEST EQUIP STANDARDS ARE IMPLEMENTED PER REQMTS OF MIL SPECS. THE FOLLOWING ITEMS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSPECTION POINTS-PARTS PROTECTION, MFG. PROCESSES, FINISHES, ASSY AND THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 11-1-76. CORROSION PROTECTION PROVISIONS, TEST HANDLING, AND STORAGE ENVIRONMENTS. BOTH CERTIFIED WELDERS AND CERTIFIED INSPECTORS ARE USED FOR ALL WELDS. TURNAROUND - BUBBLE POINT TESTS ARE PERIODICALLY PERFORMED IN THE SYSTEM AS PART OF CHECKOUT PROCEDURE PRIOR TO FLIGHT. PRESSURE CYCLES ACCUMULATED ARE ALSO RECORDED. (D) NO IN-FLIGHT FAILURE EXPERIENCE FOR THIS DESIGN.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-211120-1

ITEM Gimbal Joint FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [X] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [ ] *NO [X]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In-flight detectability
[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection gives first indication.

2. Fuel tank outlet pressure measurements V42P2310, 3310 were omitted from the FMEA and need to be added.

3A. Low pressure transducer signals could be used by software to isolate the system automatically if desired.

6. There is one success path remaining after first failure. Cross-feed.

8B. Same as primary.

SUBSYSTEM: [illegible] - PROPELLANT CONTROL
CRITICALITY: 1R PROPELLANT FEED
APPLICABLE [illegible]-[illegible]2 (MMAC)
APPLICABLE [illegible]-[illegible] REV A (SSP)
CRITICALITY: 1R
1 PER PROP TANK

PREPARED BY: [illegible]-2 [illegible]-1 REVISED [illegible]
AGENT: CRIT. ITEMS: [illegible]
[illegible] FAIL: [illegible]
MISSIONS: [illegible]
PHASE(S): [illegible]
NUMBER OF SUCCESS PATHS [illegible]
SYSTEM FIRST IDENTIFIED:
REDUNDANCY SCREEN: A-[illegible] B-[illegible] C-[illegible]

[illegible] DATA AVAILABLE IN REPORT: YES
[illegible] TANK PRESS 2110 2115 2115 2115
[illegible] 2210 REG 2310,2320
(FLOW SCHEMATIC [illegible])
FAILURE TOLERANCE/REDUNDANCY.....YES
VISUAL INSPECTION GAS LEAK CHECKS

TIME TO EFFECT:
[illegible] 0 TO [illegible] DAYS
REFERENCE DOCUMENTS:
VL321-[illegible] DV
V070-[illegible])
MJ- [illegible]-13
SM72-[illegible]-2

PREPARED BY: [illegible] N CLAVINICH C M AKERS
APPROVED BY: PLS _____ RCL _____

ITEM: [illegible] CONNECTOR
PL-X1 LI, SIGNAL JOINT.
FUNCTION:
AN [illegible]/ELLY CONSTRAINED PROPELLANT (UNIVERSAL SIGNAL JOINT [illegible]) IN THE PROPELLANT TANK OUTLET LINES TO ALLOW MOVEMENT OF THE [illegible] STAGES. CONNECTING TUBES ARE WELDED TO THE [illegible] PROP LINES.
FAILURE MODE: STRUCTURAL FAILURE (S)
EXTERNAL LEAKAGE.
CAUSE(S):
FATIGUE, CRACK, [illegible] INADEQUATE PENET, INCOMP FUSION, POROSITY, CORROS RESULTING IN PIN HOLE LEAK THRU CONVOLUTE, PROOF & BURST PRESSURE STRESS RUPTURE, FLOW INDUCED VIB-FUEL DEFECT, FLT VIB.
EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) SUBSYSTEM MALFUNCTION - LOSS OF PROPELLANT. (B) DEGRADATION OF INTERFACE FUNCTION - HOT GASES CAUSE DAMAGE WITHIN POD AND ADVERSE EFFECT ON OMS (MOLECULAR VENTING). (C) LAUNCH DELAY OR ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE - IF FELLOWS JOINT SEPARATES RESULTING IN [illegible] PROP REACTS WITH HOT GASES CAUSING FIRE OR EXPLOSION.
COMPENSATING ACTION:
ISOLATE LEAK AT TANK ISOL VLVS. UTILIZE OMS PROP AS REQ'D. ABORT MAY BE REQ'D.
REMARKS/RATIONALE:
DECOMPOSITION PROD FREE PROPELLANTS. NOT TOXIC HAZ TO CREW CREW. DECOMP NOT CATASTROPHIC FLOW SLOW UNLESS AIR OR CATALYST PRESENT. HEAT SHIELD ENVIR IS SLOW. REF HAZ NO. 1YXX-0302-00.

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :PROPELLANT FEED
P/N RI :73P550015-101&102 (MDAC)
P/N VENDOR:1008099-101&102 (SSP)
QUANTITY :12
:3 PER PROP TANK
:

FMEA NO 03-2A -211120-1 REV:11/03/78
ABORT: CRIT. FUNC: 1
CRIT. HDW: 1
MISSIONS: RF VF X FF OF SM
PHASE(S): PL X LO X CO X DO X LS X

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES N GLAVINICH
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY (NASA):
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

ITEM: CONNECTOR
FLEXIBLE, GIMBAL JOINT.

FUNCTION:
AN EXTERNALLY CONSTRAINED BELLOWS (UNIVERSAL SOCKET JOINT ASS'Y) IS PROVDED FOR THE PROPELLANT TANK OUTLET LINES TO ALLOW MOVEMENT DURING PRESSURE SURGES. CONNECTING TUBES ARE WELDED TO THE BELLOWS AND TO THE PROP LINES.

FAILURE MODE: STRUCTURAL FAILURE (S)
EXTERNAL LEAKAGE.

CAUSE(S):
FATIGUE, SHOCK, HANDLING INADEQ WELD PENET., INCOMP FUSION, POROSITY, CORROS RESULTING IN PIN HOLE LEAK THRU CONVOLUTE, PROP & SI-PROP EXPOSURE PRESS SURGE, FLOW INDUCED VIB-POGO EFFECT, FLT VIB.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) SUBSYSTEM DEGRADATION - LOSS OF PROPELLANT. (B) DEGRADATION OF INTERFACE FUNCTION - POSS CORROS DAMAGE WITHIN PCD AND ADVERSE EFFECT ON TPS (MOLECULAR VENTING). (C) LAUNCH DELAY OR ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE - IF BELLOWS JOINT RUPTURES RESULTING IN INABILITY TO UTILIZE/DEPLETE PROP OR PROP REACTS WITH FUEL OR OX CAUSING FIRE OR EXPLOSION.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) MULTIPLE BELLOWS ARE UTILIZED. FLOW INDUCED VIBRATION ANALYSIS AND STRESS ANALYSIS ARE CONDUCTED TO VERIFY ACCEPTABLE DESIGN. THE EXTERNAL CONSTRAINT (UNIVERSAL SOCKET JOINT ASS'Y) WOULD TEND TO LIMIT ANY GROSS PROPELLANT LEAK IN EVENT OF BELLOWS FAILURE. ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITION. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 8-29-77. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L CONFORMANCE TO CONTRACT REQMTS. TURNAROUND - MONITOR LEAKAGE TESTS PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND AS PART OF CHECKOUT

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -211120-1 REV:11/08/78

PROCEDURE PRIOR TO FLIGHT. (0) NO FAILURE HISTORY AVILABLE ALTHOUGH THE APOLLO PROGRAM DID SHOW SOME PROBLEMS ON FLEX HOSE ASSY DUE TO PIN HOLE CORROSION ASSOC. WITH RESIDUAL SOLVENTS AND PROPELLANT.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST

SUBSYSTEM AFT-RCS FMEA NUMBER 03-2A-221308-1

ITEM Bellows Assy. FAILURE MODE External Leakage

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ]	*NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In-flight detectability

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. Gross leak detection gives first indication.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL FMEA NO 03-2A -221308-1 REV:11/08/78
ASSEMBLY :THRUSTER/PROPELLANT FEED ABORT: CRIT. FUNC: 1
P/N RI :MC621-0059 CRIT. HDW: 1
P/N VENDOR:73P55003-1001THRU1005 MISSIONS: HF VF X FF OF SM
QUANTITY :56 PHASE(S): PL X LO X CO X DO X LS X
:ONE FUEL AND ONE OXIDIZ.
:PER THRUSTER(PRI & VERN)
REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES N GLAVINICH
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY(NASA):
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

ITEM: BELLOWS ASSEM.,
ENGINE ALIGNMENT.
FUNCTION:
A STAINLESS STEEL EXTERNALLY (CYLINDER) CONSTRAINED BELLOWS WITH RIGID TUBE END CONNECTIONS IS PROVIDED AS A MEANS OF CONNECTING AND ALIGNING THE THRUSTER VALVES TO THE PROPELLANT SYSTEM.
FAILURE MODE: STRUCTURAL FAILURE (S)
EXTERNAL LEAKAGE.
CAUSE(S):
FATIGUE, SHOCK, HANDLING, INADEQ WELD PENET, INCOMP FUSION, POROSITY, CORROS-PROP & BI-PROP EXPOSURE, PRESS SURGE, FLOW INDUCED VIB-POGO EFFECT, FLT VIB.
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) SUBSYSTEM DEGRADATION - LOSS OF PROPELLANT. (B) DEGRADATION OF INTERFACE FUNCTION - POSS CORROS DAMAGE WITHIN POD AND ADVERSE EFFECT ON TPS (MOLECULAR VENTING). (C) LAUNCH DELAY OR ABORT DECISION. (D) POSSIBLE LOSS OF CREW/VEHICLE - FAILURE NOT DETECTABLE SINCE PVT MEASUREMENTS HAVE BEEN DELETED FROM SOFTWARE FOR ASCENT AND RTLS. (ISOLATION IS POSSIBLE DURING OTHER MISSION PHASES).
DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) MULTIPLE BELLOWS ARE UTILIZED. FLOW INDUCED VIBRATION ANALYSIS AND STRESS ANALYSIS WERE CONDUCTED TO VERIFY ACCEPTABLE DESIGN. THE EXTERNAL CONSTRAINT WOULD TEND TO LIMIT ANY GROSS PROPELLANT LEAK IN EVENT OF BELLOWS FAILURE. PROPELLANT LEAK FROM LINE TO THRUSTER COULD BE ISOLATED BY MANIFOLD VALVE. (B) ITEM IS USED DURING SYSTEM EVALUATION TESTS AT WSTF ALLOWING EVALUATION UNDER SIMULATED MISSION USAGE CONDITION. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, INSP FOR SURFACE AND SUBSURFACE DEFECTS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 8-29-77. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L CONFORMANCE TO CONTRACT REQMTS. TURNAROUND - MONITOR LEAKAGE TESTS PERFORMED AFTER INSTALLATION INTO THE SYSTEM AND AS PART OF CHECKOUT PROCEDURE PRIOR TO FLIGHT. (D) NO FAILURE HISTORY AVAILABLE ALTHOUGH THE APOLLO PROGRAM DID SHOW SOME PROBLEMS ON FLEX HOSE ASSY DUE TO PIN HOLE CORROSION ASSOC. WITH RESIDUAL SOLVENTS AND PROPELLANT.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-221310-4

ITEM Engine Inlet Valve FAILURE MODE Fails Closed

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X] *NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [X] NO [ ]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [ ] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [X] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed off" thruster C&W.

NASA FMEA FAILURE MODE AND EFFECTS ANALYSIS - [illegible]

SUBSYSTEM: RCS - REACTION CONTROL   FMEA NO [illegible]   [illegible]
. ASSEMBLY : THRUSTER, PRIMARY   ABORT: [illegible]
. P/N RI : [illegible]
. P/N VENDOR: [illegible]   MISSIONS: [illegible]
. QUANTITY : [illegible]   PHASE(S): [illegible]
. : [illegible] FUEL AND [illegible] OXIDIZER   NUMBER OF SUCCESS PATHS REMAINING
. :   AFTER FIRST FAILURE:
.   REDUNDANCY SCREENS: A-PASS B-FAIL C-
. [illegible] DETECTABLE IN FLIGHT?: YES   TIME TO EFFECT:
. [illegible] LOCATION   CREW PROCESS   IMMEDIATE
. [illegible]   REFERENCE DOCUMENTS:
.   VS70-[illegible]
. [illegible] TURNAROUND?..............YES   [illegible]
. [illegible] TRICKLE CURRENT TEST FOR   SD72-SH-[illegible]
. CONTINUITY   MC421-[illegible]
.
.
. PREPARED BY: APPROVED BY:
. DES   W SEARCY   DES ____________________
. REL   C M AKERS   REL ____________________
.
.
. ITEM: INLET VALVE, ENGINE,
. PILOT OPERATED, SOLENOID DRIVEN (28 VOLTS DC) [illegible]
. FUNCTION:
. VALVES ARE USED TO INITIATE THRUSTER FIRING BY OPENING [illegible] [illegible]. AN OX AND A FUEL VALVE ARE PROVIDED FOR EACH THRUSTER.
. FAILURE MODE: FAILS CLOSED (F)
. FAILS TO OPEN, FAILS TO REMAIN OPEN.
. CAUSE(S):
. [illegible] OR JAMMING OF POPPET OR ARMATURE, [illegible] CONTAM, CORROS, WEAR, VIB, SHOCK, ELECT FAILURE, [illegible] DAMAGE.
. EFFECT(S) ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
. (A) LOSS OF REDUNDANCY - LOSS OF USE OF 1 THRUSTER. (B) DEGRADATION OF [illegible] FUNCTION - GNCC MUST CHOOSE OTHER THRUSTERS TO PERFORM FUNCTION. (C) NO EFFECT. (D) NO EFFECT. (E) FUNCTIONAL CRITICALITY EFFECT - POSSIBLE LOSS OF CREW VEHICLE DUE TO LOSS OF RCS IF ALL REDUNDANT THRUSTERS AFFECTED.
. CORRECTING ACTION:
. [illegible] CONFIGURE [illegible]. UTILIZE REMAINING THRUSTERS ([illegible] OPERATION DURING RTLS IF POSSIBLE).
. REMARKS/HAZARDS:
. NO HAZARDS IDENTIFIED FOR NORMAL MISSION. LANDING HAZ, AERODYNAMIC CONTROL, TOXIC, FIRE & EXPLOSION IF OMS/RCS PROP NOT DEPLETED PRIOR TO LANDING (RTLS). MAY OBTAIN AVAIL FOR ERRONEOUS FAIL [illegible] CONS. LOSS OF THRUSTER NOT CONSIDERED CRITICAL FOR RTLS FOR THE CRITTER FLIGHT TEST VEHICLE. REF HAZ NO IYXX-0307-05.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-221311-1

ITEM Injection Plate FAILURE MODE Restricted Flow

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [X] NO [ ]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ] *1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

In-Flight Detectability

[X] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed off" thruster C&W.

FAILURE MODE AND EFFECTS ANALYSIS - SECTION 2.0

SUBSYSTEM: SAFI - REACTION CONTROL
ANALYST: [illegible], PRIMARY
DATE: [illegible]
APPROVED: [illegible]
MISSION: [illegible]
PHASE(S): [illegible]
NUMBER OF SUCCESS PATHS REMAINING AFTER FIRST FAILURE:
REDUNDANCY SCREEN: A-PASS B-FAIL C-

CRITICALITY CATEGORY: [illegible]
REMARKS: [illegible]
REFERENCE DOCUMENTS:
VS7C-[illegible]
MJ07C-[illegible]
SD72-SH-[illegible]
MC621-[illegible]

PREPARED BY: [illegible] APPROVED BY: [illegible]
[illegible] [illegible]

ITEM: INJECTOR, PLATE

FUNCTION:
PROVIDES INJECTION & VAPORIZATION OF FUEL AND OXIDIZER PROPELLANTS INTO VALVE AND PROVIDES ACOUSTIC MIXING AT LOCATION TO PRODUCE HYPERGOLIC REACTION WHICH PRODUCES HOT POUNDS OF THRUST AT [illegible] PSIA. FLOW CONTROL ORIFICES WILL BE [illegible]. THE INJECTOR IS CONSTRUCTED OF [illegible] CONSTRUCTION & WELDED TO THE CASE CHAMBER. ACOUSTIC CAVITIES ARE LOCATED AT THE OUTER PERIPHERY OF THE END FACE TO PREVENT HIGH FREQUENCY INSTAB.
FAILURE MODE: FAILS OUT OF TOLERANCE (F)
OF RESTRICTED FLOW.
CAUSE(S):
CONTAMINATION, PRODUCTS OF COMBUSTION BLOCKING ORIFICES, BRAZING OF PROPELLANTS.
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY OR FUNCTIONAL DEGRADATION - REDUCED THRUST [illegible] (B) NO EFFECT. (C) NO EFFECT. (D) NO EFFECT. (E) FUNCTIONAL CRITICALITY OF [illegible] DECISION - DEGRADED PERFORMANCE OF REDUNDANT THRUSTERS NEEDED REQUIRED MISSION ABORT.
CORRECTIVE ACTION:
SWITCH TO REDUNDANT INJECTOR IN AFFECTED AXIS. AUTOMATIC SWITCH OVER BY [illegible] DETECTION SYS. VERIFY ISOL VLVS OPEN.
REMARKS/HAZARDS:
POTENTIAL HAZARD FROM CHAMBER BREAKING OR HOT SPOTS RESULTING IN CHAMBER FAILURE. LANDING HAZ. AERODYNAMIC CONTROL, RENTRY, FIRE & EXPLOSION IF LMS/RCS PROP NOT DEPLETED PRIOR TO LANDING (TILS). LOSS OF THRUST NOT CONSIDERED CRITICAL FOR ATLS FOR ORBITER FLIGHT TEST

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :THRUSTER, PRIMARY
P/N RI :MC467-0028
P/N VENDOR:X30938
QUANTITY :24
:ONE INJECTOR PROVIDED FO
:R EACH PRIMARY THRUSTER

FMEA NO 03-2A -221311-I REV:11/03/78
ABORT: CRIT. FUNC: 2
CRIT. HDW: 3
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO X CO X OO X LS

REDUNDANCY SCREEN: A-PASS B-FAIL C-PASS

PREPARED BY:
DES W SEARCY
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY NASA:
SSM
REL

DELETE
See Section 13.0

ITEM: INJECTOR, PLATE

FUNCTION:
PROVIDES INJECTION & VAPORIZATION OF FUEL AND OXIDIZER FROM THRUSTER INLET VALVES AND PROVIDES DOUBLET MIXING AT 1.60 OX TO FUEL RATIO FOR A HYPERGOLIC REACTION WHICH PRODUCES 825 POUNDS OF THRUST AT 70,000 FEET. ALSO CONTROL CHAMBER WALL COOLING. THE INJECTOR IS CONSTRUCTED OF C-103 COLUMBIUM & WELDED TO THE COMB CHAMB. ACOUSTIC CAVITIES ARE LOCATED AT THE OUTER PERIPHERY OF THE INJ FACE TO PREVENT HIGH FREQ COMB INSTAB.

FAILURE MODE: FAILS OUT OF TOLERANCE (F)
AT RESTRICTED FLOW.

CAUSE(S):
CONTAMINATION, PRODUCTS OF COMBUSTION BLOCKING ORIFICES, FREEZING OF PROPELLANTS.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY OR FUNCTIONAL DEGRADATION - REDUCED PROP FLOW-CHAM PRESS & THRUST, INADEQ CHAM/INJ FILM COOLING. (B) DEGRADATION OF INTERFACE FUNCTION-INCR GN&C & USE OF ALT THRUSTERS (C) NO EFFECT. (D) NO EFFECT. (E) FUNCTIONAL CRITICALITY EFFECT - ABORT DECISION - DEGRADED PERFORMANCE OF REDUNDANT THRUSTERS WOULD REQUIRE MISSION ABORT.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
74 MICRON NOMINAL FILTERS ARE PROVIDED TO CONTROL CONTAMINATION FROM SYS AND SUBSEQUENT HAZARD. AUTOMATIC SWITCH OVER (AND ISOLATION) BY GN&C FAILURE DETECTION SYS. COMPLETE THERMAL AND STRESS ANALYSIS HAVE BEEN COMPLETED. (B) RCS SYS EVAL TEST AT WSTF. THRUSTER QUAL FOR 50,000 CYCLES. SPRAY PATTERN CHECKED DURING ATP. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 9-2-76. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND INSPECTION TO INCLUDE USE OF OPTICS WHERE ACCESSIBLE TO DETERMINE EVIDENCE OF PLUGGED ORIFICE. FLUID SAMPLING TO BE PERFORMED TO DETECT CONTAMINATION. (D) NO DIRECT FAILURE HISTORY AVAILABLE.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-221312-1

ITEM Thrust Chamber FAILURE MODE Burn-Thru

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [X]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ]	*NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [X]	NO [ ]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X]	NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed off" thruster C&W.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - CRITICAL

[illegible] : [illegible] AREA NO [illegible] [illegible] [illegible]
[illegible] : [illegible] ANSRT: [illegible]
[illegible] : [illegible] [illegible]
[illegible] : [illegible] MISSIONS: [illegible]
[illegible] : [illegible] PHASE(S): [illegible]
[illegible] : [illegible] NUMBER OF SUCCESS PATHS REMAINING
[illegible] : [illegible] AREA PHASE FAILURES:
REDUNDANCY SCREEN: A-[illegible] B-[illegible] C-[illegible]

CRITICAL ITEM: [illegible]
[illegible] IDENTIFICATION NO. ON EACH ENGINE, V42P-2521 THRU V42P-2524
V42P-2519 AND V42P-2521 THRU V42P-2524

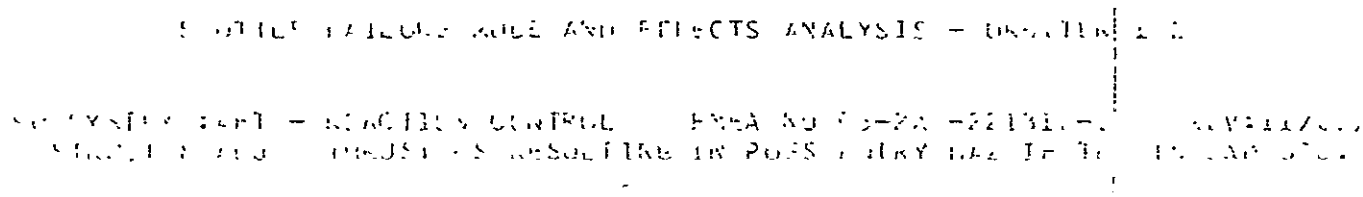
SYSTEM REDUNDANCY?.....YES
VISUAL INSPECTION

IMPACT IF OCCURS:
SECONDS
REFERENCE DOCUMENTS:
VL70-[illegible]
MJC70-[illegible]-01A
S072-SE-FIC0-2

PREPARED BY:
DES W SEARCY
REL C M AKERS

APPROVED BY:
DES _____
REL _____

ITEM: THRUST CHAMBER
MAIN INJECTOR TO NOZZLE EXTENSION (COATED COLUMBIAN).
FUNCTION:
TO CONFINE HYPERGOLIC REACTION OF PROPELLANTS AND DIRECT EXHAUST PRODUCTS THROUGH NOZZLE & EXTENSION TO PROVIDE IMPULSE TO VEHICLE. IT CHAMBER IS CONSTRUCTED OF C-103 COLUMBIUM WITH R-512 A OXIDATION RESISTANT COATING AND UTILIZES FILM COOLING. THE CHAMBER PORTION OF THE UNIT IS DESIGNED TO PRODUCE A THRUST OF 37,500 LBS VACUUM AT A NOMINAL STEADY STATE SPECIFIC IMPULSE OF 285 SECONDS.
FAILURE MODE: STRUCTURAL FAILURE (S)
BURN THRU OR RUPTURE IN CHAMBER.
CAUSE(S):
THERMAL CYCLING/STRESS FATIGUE, VIB, COMB INSTAB, SHOCK. PLUGGED INJ ORIFICES, HIGH TEMP/LOCALized HOT SPOTS/INADEQ COOLING NOZZLE RESTRICTION.
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY-POSS LOSS OF 3 THRUSTERS IF MANIFOLD ISOL VALVE MUST BE CLOSED. (B) DEGRADATION OF INTERFACE FUNCTION-MAY CAUSE LOSS OF ALL THRUSTERS (C) MISSION MODIFICATION/ABORT DECISION OF FAILURE CAUSES DAMAGE PROPAGATION. (D) POSSIBLE LOSS OF CREW/VEHICLE BURN-THRU MAY CAUSE HIGH TEMP DAMAGE TO SURR STRUCT & ADJ THRUSTERS RESULTING IN POSS ENTRY HAZ IF THIS IS DAMAGED.
CORRECTIVE ACTION:
ISOLATE PROPELLANTS FROM THRUSTER (AT MANIFOLD LEVEL) AND ASSESS FOR LEAKAGE AND DAMAGE TO SURROUNDING STRUCTURE.
REMARKS/HAZARDS:
LOSS HAZ IF OMS/RCS PUMP NOT DEPLETED PRIOR TO LOSS (RTLS). ALSO IF FCP RTLS AT SEP (DOWN FIRING). THERE IS NO AUTO THRUSTER ISOL AFTER BURN INITIATION (DURIN FIRING). HOT IMPINGMT OF HOT GASES ON MANIFOLD STRUCT & ADJ THRUSTERS. BURN-THRU MAY CAUSE HIGH TEMP DAM TO SURR



SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :THRUSTER, PRIMARY
P/N RI :MC467-0028
P/N VENDOR:X30958
QUANTITY :24
:ONE PER THRUSTER
:

FMEA NO 03-2A -221312-1 REV:11/08/78
ABORT: CRIT. FUNC: 1
CRIT. HDW: 1
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO X OO X DO X LS

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES W SEARCY
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY NASA:
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

ITEM: THRUST CHAMBER
FROM INJECTOR TO NOZZLE EXTENSION (COATED COLUMBIAN).

FUNCTION:
TO CONTAIN HYPERGOLIC REACTION OF PROPELLANTS AND DIRECT COMBUSTION PRODUCTS THROUGH NOZZLE & EXTENSION TO PROVIDE IMPULSE TO VEHICLE. THE CHAMB IS CONSTRUCTED OF C-103 COLUMBIUM WITH R-512 A OXIDATION RESISTANT COATING AND UTILIZES FILM COOLING. THE CHAMB PRESS IS 152 PSI & IS DESIGNED TO PRODUCE A THRUST OF 870 LBS VACUUM AT A NOMINAL STEADY STATE SPECIFIC IMPULSE OF 280 SECONDS.

FAILURE MODE: STRUCTURAL FAILURE (S)
BURN THRU OR RUPTURE IN CHAMBER.

CAUSE(S):
THERMAL CYCLING/STRESS FATIGUE, VIB, COMB INSTAB, SHOCK. BLOCKED INJ ORIFICES, HIGH TEMP/LOCALIZED HOT SPOTS/INADEQ COOLING NOZZLE RESTRICTION.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY-POSS LOSS OF 3 THRUSTERS IF M'FOLD ISOL VALVE MUST BE CLOSED. (B) DEGRADATION OF INTERFACE FUNCTION-INCR GN&C & USE OF ALT THRUSTERS (C) MISSION MODIFICATION/ABORT DECISION IF FAILURE CAUSES DAMAGE PROPAGATION. (D) POSSIBLE LOSS OF CREW/VEHICLE BURN-THRU MAY CAUSE HIGH TEMP DAMAGE TO SURR STRUCT & ADJ THRUSTERS RESULTING IN POSS ENTRY HAZ IF TPS IS DAMAGED.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) STRUCTURAL MARGINS (2.0 TO 4.0) MINIMIZE FAILURE EFFECT(S). ENG DESIGNED TO INGEST UP TO 45 CU. IN. OF GAS. (B) RCS SYS EVAL TEST AT WSTF. THRUSTER QUAL FOR 50,000 CYCLES. (C) A VISUAL INSP. AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 9-2-76. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MATL AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND INSPECTION TO INCLUDE USE OF OPTICS WHERE ACCESSIBLE TO DETERMINE EVIDENCE OF PLUGGED ORIFICE. FLUID SAMPLING TO BE PERFORMED TO DETECT CONTAMINATION. (D) NO DIRECT FAILURE HISTORY AVAILABLE.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-221313-1

ITEM Nozzle Extension FAILURE MODE Burn-Thru

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [ ]	NO [X]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [ ]	NO [X]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ]	NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [ ]	*1 [ ] 2 [X]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

[illegible]SYSTEM : OMS - PROPULSION SUBSYSTEM
[illegible]ASSEMBLY : THRUSTER, PRIMARY
[illegible] NO. : MC07-0[illegible]
[illegible] QUANTITY : 2
: PER VEHICLE
:

AREA ANALYZED-ONE ASSEMBLY
[illegible]HERE:
MISSION: [illegible]
PHASE(S): [illegible]
NUMBER OF SUCCESS PATHS REMAINING:
[illegible] FIRST FAILURE:
REDUNDANCY SCREEN: A-N/A B-N/A C-
[illegible] IF EFFECT:
[illegible]
[illegible] DEPENDENTS:
VS70-[illegible]
MJC70-[illegible]
SF72-SR-[illegible]
M621-[illegible]

[illegible] ACCEPTABLE IN FLIGHT? YES
[illegible] TEMP RISE
[illegible]

SOURCE TURNAROUND?.....YES
VISUAL INSPECTION

PREPARED BY:
[illegible] S
[illegible]

[illegible] SEARCY
[illegible] MARKS

APPROVED BY:
[illegible]
[illegible]

ITEM: NOZZLE EXTENSION,
COOLED COLUMBIUM (WITH INSULATION BLANKET).
FUNCTION:
PROVIDE ISENTROPIC EXPANSION OF COMBUSTION GASES FOR MAXIMUM [illegible]
VACUUM. NOZZLE IS CONSTRUCTED OF C-103 COLUMBIUM ALLOY WITH SILICIDE
RESISTANT COATING. THE NOZZLE EXPANSION RATIO IS 40 TO 1. THE NOZZLE
IS INTEGRAL WITH THE CLAMP CHAVE AND ENCLOSED IN A DYNA FLEX INSUL
BLANKET SO THAT THE EXIT TEMP IS MAINTAINED PER THE PROPULSION
SPECIFICATION REQMT.
FAILURE MODE: STRUCTURAL FAILURE, (S)
BURN-THRU.
CAUSE(S):
HIGH TEMPERATURE IN LOCAL SPOT CONTAMINATED INJECTOR COOLANT HOLES FOR
OR METAL DEFECT.
EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY-POSS LOSS OF 2 THRUSTERS IF [illegible] LEVEL
MOST OF CLOSED. (B) DEGRADATION OF INTERFACE FUNCTION-LOSS CONTROL
OF ALL THRUSTERS. BURN-THRU MAY CAUSE HIGH TEMP DAMAGE TO SURR STRUCT,
TVC, & ADJ THRUSTERS (C) MISSION TERMINATION/ABORT REQUIRED. IF
FAILURE CAUSES DAMAGE PROPAGATION. (D) LOSS OF CREW/VEHICLE-BURN
THRU MAY CAUSE HIGH TEMP DAMAGE TO SURR STRUCT & ADJ STRUCTURES
RESULTING IN POSS ENTRY GAP IF TPS IS DAMAGED
CORRECTING ACTION:
ISOLATE THRUSTER AT INLET VALVE OR MANIFOLD AND ASSESS FOR LEAKAGE AND
DAMAGE TO SURROUNDING STRUCTURE.
REMARKS/RATIONALE:
LONG HAZ IF OMS/RCS PROP NOT DEPLETED PRIOR TO LONG (HRS). ALSO LONG
[illegible] HRS OF SSME (DOWN FIRING). THERE IS NO AUTO THRUSTER ISOL AFTER
BURN INITIATION (DURING FIRING). NOT IMPACKT IF NOT BASED ON MODEL
STUDY [illegible] ADJ THRUSTERS. BURN-THRU MAY CAUSE HIGH TEMP DAM TO SURR

[illegible]

ORIGINAL PAGE IS
OF POOR QUALITY

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :THRUSTER, PRIMARY
P/N RI :MC467-0028
P/N VENDOR:X30872
QUANTITY :24
:ONE PER THRUSTER
:

FMEA NO 03-2A-221313-1 REV:11/08/78
ABORT: CRIT. FUNC: 1
CRIT. HDW: 1
MISSIONS: NF VF X FF OF SM
PHASE(S): PL LO X CO X DO X LS

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES W SEARCY
REL C M AKERS

APPROVED BY:
DES
REL 12/79

APPROVED BY (NASA):
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

ITEM: NOZZLE EXTENSION,
COATED COLUMBIUM (WITH INSULATION BLANKET).

FUNCTION:
TO PROVIDE ISENTROPHIC EXPANSION OF COMBUSTION GASES FOR MAX EFF IN VACUUM. NOZ EXT IS CONSTRUCTED OF C-103 COLUMBIUM WITH R-512A OXIDATION RESISTANT COATING. THE NOZZLE EXPANSION RATIO IS 22 TO 1. THE NOZ EXT IS INTEGRAL WITH THE COMB CHAMB AND ENCLOSED IN A DYNA FLEX INSUL SHROUD SO THAT THE EXT TEMP IS MAINTAINED PER THE PROCUREMENT SPECIFICATION REQM'T.

FAILURE MODE: STRUCTURAL FAILURE, (S)
BURN-THRU.

CAUSE(S):
HIGH TEMPERATURE IN LOCAL SPOT CONTAMINATED INJECTOR COOLANT HOLES WELD OR MAT'L DEFECT.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF REDUNDANCY-POSS LOSS OF 3 THRUSTERS IF MANIFOLD ISOL VALVE MUST BE CLOSED. (B) DEGRADATION OF INTERFACE FUNCTION-INCR GN&C & USE OF ALT THRUSTERS. BURN-THRU MAY CAUSE HIGH TEMP DAM TO SURR STRUCT, TPS, & ADJ THRUSTERS (C) MISSION MODIFICATION/ABORT DECISION IF FAILURE CAUSES DAMAGE PROPAGATION. (D) LOSS OF CREW/VEHICLE-BURN THRU MAY CAUSE HIGH TEMP DAMAGE TO SURR STRUCT & ADJ STRUCTURES RESULTING IN POSS ENTRY HAZ IF TPS IS DAMAGED

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) HIGH THERMAL MARGINS IN NOZZLE EXTENSION AND HIGH COOLING MARGIN WILL MINIMIZE FAILURE EFFECT. ENG DESIGNED TO INGEST 45 CU. IN. OF GAS. THRUSTER CAN BE ISOLATED AT INLET OR MANIFOLD VALVE. (B) RCS SYS EVAL TEST AT WSTF. THRUSTER QUAL FOR 50,000 CYCLES. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS AE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 9-2-76. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND INSPECTION TO INCLUDE USE OF OPTICS WHERE ACCESSIBLE TO DETERMINE EVIDENCE OF BURN-THRU. (D) NO DIRECT FAILURE HISTORY AVAILABLE.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-231310-1

ITEM Vernier Thruster FAILURE MODE Loss of Output

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X]	NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X]	NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X]	*NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [X]	NO [ ]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ]	NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ]	NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ]	NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X]	*1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ]	YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:		
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X]	*NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X]	*NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

3. Down modes to free drift.

6. No redundancy in the verniers.

SPACELAB FAILURE MODE AND EFFECTS ANALYSIS - [illegible] 306

[illegible]: RCS - REACTION CONTROL
[illegible]: VERNIER THRUSTER
[illegible]:
[illegible]:
QUANTITY: 24
: 2 PER POD
: 12 PODS, 1 YAW

MPAA NO. 83-1A-[illegible]-[illegible] REVISION:
ABORT: CRIT. FUNC:
CRIT. PH :
MISSIONS: MS VEHICLE [illegible]
PHASE(S): PL LO [illegible] LS
NUMBER OF SUCCESS PATHS REMAINING
AFTER FIRST FAILURE:
REDUNDANCY SCREEN: A-PASS B-PASS C-PASS D-
TIME TO EFFECT:
IMPACT:
REFERENCE DOCUMENTS:
MC 421-0059
MJ07C-0001-0010
SC72-SM-C1001-2
VS70-421-01

VALVE DETECTABLE IN FLIGHT? YES
POSITION CHANGE PRESS.

LOCAL TURNAROUND?.....YES
POSITION INDICATION

PREPARED BY:
DES J TAGGART
REL C M AKERS

APPROVED BY:
DES _____
REL _____

ITEM: THRUSTER, ASSY, VERNIER
[illegible] THRUST LEVEL. EA 257/258/259/260.
FUNCTION:
ONE PITCH (+ Y AXIS-UP FIRING) AND ONE YAW (PLUS/MINUS Y AXIS) VERNIER THRUSTERS ARE PROVIDED IN EACH ARCS MODULE TO PROVIDE PRECISE LOW LEVEL PULSING & D ATTITUDE CTLG REQ'D FOR PAYLOAD POINTING. THEY ARE CONCEPTUALLY SIMILAR TO THE PRIMARY THRUSTER BUT LIGHT FLUX IMPINGEMENT AND PROP RESIDUE CONTAM TO THE PAYLOAD.
FAILURE MODE: LOSS OF OUTPUT(THRUST) (F)
INLET VALVES CLOSED OR INJ ORIFICE PLUGGED.
CAUSE(S):
OPEN SOL COIL, AUTO SHUT-DOWN, INLET VLV LEAK/STRUCT FAIL, INJ CONTAM/RESIDUE OR FROZEN PROP BLOCKING ORIFICE, CONT CHAN/MOD STRUCT FAIL.
EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION (VERNIER THRUSTERS)-CURRENTLY LOST OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL. (B) NO EFFECT. (C) MISSION MODIFICATION OR ABORT DECISION (POTENTIAL INABILITY TO RETRIEVE PAYLOAD). - IT IS POSSIBLE PAYLOAD COULD BE RETRIEVED WHILE IN FREE DRIFT MODE AND IN SOME INSTANCES PAYLOAD MAY HAVE ATTITUDE & TRANSLATION CONTROL. IT MAY BE POSSIBLE TO USE FWD & AFT RCS (X AXIS) ENGINES FOR PITCH (DOWNWARD) MOTION. (D) NO EFFECT.
CORRECTING ACTION:
EVALUATE TO DETERMINE NEED FOR ABORT VERSUS USE OF PRIMARY THRUSTERS, FREE DRIFT MODE OR PAYLOAD ATTITUDE CONTROL.
REMARKS/HAZARDS:
NO HAZARDS IDENTIFIED. PRIMARY THRUSTERS MOVE VEHICLE TO MINIMIZE RE-ENTRY OF PAYLOAD. PAYLOAD BAY ARMS ARE 55 FT LONG. (THEY ARE NOT DESIGNED TO WITHSTAND FORCES OF PRIMARY THRUSTING). IT IS POSSIBLE PAYLOAD COULD BE RETRIEVED WHILE IN FREE DRIFT MODE AND IN SOME INSTANCES PAYLOAD MAY

[illegible] - [illegible] SMIA NO 30-2A -[illegible]-1 [illegible]
[illegible] ATTITUDE & TRANSLATION CONTROL. IT MAY BE POSS[illegible]
[illegible] (X AXIS) [illegible] PITCH (Y AXIS) MOTION.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :VERNIER THRUSTER
P/N RI :MC467-0029
P/N VENDOR:
QUANTITY :4
:2 PER POD
:1 PITCH, 1 YAW

FMEA NO 03-2A -231310-1 REV:11/08/75
ABORT: CRIT. FUNC: 2
CRIT. HDW: 2
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO CO X OO LS

REDUNDANCY SCREEN: A-PASS B-PASS C-FAIL

PREPARED BY:
DES J TAGGART
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY (NASA):
SSM
REL

APPROVED WITH CHANGES
See Section 13.0

ITEM: THRUSTER, ASSY, VERNIER
25 POUND THRUST LEVEL. EN 357/358/257/258.

FUNCTION:
ONE PITCH (2 AXIS-UP FIRING) AND ONE YAW (PLUS/MINUS Y AXIS) VERNIER THRUSTER ARE PROVIDED IN EACH ARCS MODULE TO PROVIDE PRECISE LOW LEVEL PULSING AND ATTITUDE HOLD REQ'D FOR PAYLOAD POINTING. THEY ARE CONCEPTUALLY SIMILAR TO THE PRIMARY THRUSTER BUT LIMIT PLUME IMPINGEMENT AND PROP RESIDUE CONTAM TO THE PAYLOAD.

FAILURE MODE: LOSS OF OUTPUT(THRUST) (F)
INLET VALVES CLOSED OR INJ ORIFICE PLUGGED.

CAUSE(S):
OPEN SOL COIL, AUTO SHUT-DOWN, INLET VLV LEAK/STRUCT FAIL, INJ CONTAM/RESIDUE OR FROZEN PROP BLOCKING ORIFICE, COMB CHAM/NOZ STRUCT FAIL.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION (VERNIER THRUSTERS)-CURRENTLY LOSS OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL. (B) NO EFFECT. (C) MISSION MODIFICATION OR ABORT DECISION (POTENTIAL INABILITY TO RETRIEVE PAYLOAD). - IT IS POSSIBLE PAYLOAD COULD BE RETRIEVED WHILE IN FREE DRIFT MODE AND IN SOME INSTANCES PAYLOAD MAY HAVE ATTITUDE & TRANSLATION CONTROL. IT MAY BE POSSIBLE TO USE FWD & AFT RCS (X AXIS) ENGINES FOR PITCH (DOWNWARD) MOTION. (D) NO EFFECT.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) POSS REDUND MODES IN X AXIS PRIMARY THRUSTER, PAYLOAD ATTITUDE CONTROL & FREE DRIFT MODES. 100 MICRON FILTRATION & HEATERS PROVIDED TO LIMIT CONTAM & PREVENT PROP FREEZING. (B) THRUSTER QUAL FOR 500,000 CYCLES, 125,000 SEC BURN TIME, INLET VALVE TESTED FOR 500,000 WET CYCLES & 5000 DRY. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 9-2-76. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND - VISUAL INSP USING OPTICAL INSTRUMENTATION. SYSTEM FLUIDS ARE ANALYSED FOR EVIDENCE OF CONTAMINATION. PROPER INLET VALVE FUNCTION AND ELECTRICAL LOGIC POWER IS VERIFIED. (D) NO DIRECT FAILURE HISTORY AVAILABLE.

HARDWARE/SOFTWARE ANALYSIS CHECKLIST SD72-SH-0103-2

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-231310-2

ITEM Vernier Thruster FAILURE MODE Fails to Stop Firing

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [X] *NO [ ]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [ ] NO [X]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [ ] NO [X]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X] *1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES
2. [X] HARDWARE ACCEPTS RISK
3. [ ] NO SOFTWARE DETECTION
4. [ ] DETECTION DURING CHECKOUT
5. [ ] ACCEPTANCE RATIONALE BELOW
6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed on" thruster C&W.

6. No redundancy in the verniers.

[illegible] : [illegible] - [illegible] CONTROL — AREA NO DATA REQUIRED — [illegible]
[illegible] : MC [illegible] THRUSTER — CREW: — CRIT. PLAN: —
[illegible] : 06-07-06 29 — (SC) — [illegible]: —
[illegible]: — REQUIRED: PE VE X PF OF —
[illegible]: — TIMES (S): PE LC C A D IS
[illegible]: — NUMBER OF SUCCESS PATHS = [illegible]
[illegible]: — AFTER FIRST FAILURE:
— REDUNDANCY SCREEN: [illegible]

MAINTAINABLE IN FLIGHT: YES — TIME TO EFFECT:
[illegible] COMPUTER PRESS. AND COMPUTER DATA RELATI — IMPACT ON:
[illegible] INTELLIGENCE — REMARKS NO. & COMMENTS:
— MC 031-0[illegible]
GROUND TURNAROUND?.....YES — RTLS-SSME-[illegible]
POSITION INDICATION — SRB-SM-0[illegible]
— VST0-4[illegible]

PREPARED BY: — APPROVED BY:
DeS J TAGGART — DeS _____
REL C M AKERS — REL _____

[illegible] THRUSTER, ASSY, VERNIER
[illegible] FROM THRUST LEVEL. PN 257/258/757/758.
FUNCTION:
[illegible] PITCH (C AXIS-UP FIRING) AND YAW (PLUS/MINUS Y AXIS) VERNIER THRUSTER PAIR PROVIDED IN EACH AFT MODULE TO PROVIDE PRECISE ON ORBIT PULSING AND ATTITUDE HOLD MODE FOR PAYLOAD POINTING. THEY ARE SPECIFICALLY SIMILAR TO THE PRIMARY THRUSTER BUT LIMIT MAX THRUSTING TIME AND PROP RESIDUE CONTAIN TO THE PAYLOAD.
FAILURE MODE: FAILS TO STOP (F)
FAILS OPEN, FAILS TO CLOSE (THRUSTER CONTINUES FIRING).
CAUSE(S):
CONTAMINATION, STRUCTURAL FAILURE, DUAL SHORT IN DRIVE CIRCUIT TO BOTH A/B FIRE COMMAND, VIB, SPACE SEAL SEAT DAM, PROP RESIDUE, FLOW SALIS. CLOSURE, WEAR.
EFFECT(S): (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(-) LOSS OF FUNCTION (VERNIER THRUSTERS) - CURRENTLY LOSS OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL. (B) [illegible] OF INTERFACE SUB-SYSTEM - PROP LOSS DUE TO LACING CONTAMINATED [illegible] CAN BE ISOLATED-LOSS DAMAGE TO PAYLOAD OR PAYLOAD BY ARMS. (C) MISSION MODIFICATION OR ABORT DECISION. (D) NO EFFECT.
CORRECTIVE ACTION:
ISOLATE FAILED THRUSTER WITH UPSTREAM MANIFOLD ISOLATION VALVE. EVALUATE TO DETERMINE NEED FOR ABORT VERSUS USE OF PRIMARY THRUSTERS, [illegible] DRIFT MODE OR PAYLOAD ATTITUDE CONTROL.
REMARKS/HAZARDS:
POSSIBLE DAMAGE TO PAYLOAD OR PAYLOAD BAY ARMS. PRIMARY THRUSTERS MOVE VEHICLE WITHIN 35-40 FT OF PAYLOAD. PAYLOAD BAY ARMS ARE 50 FT LONG. IT IS POSSIBLE PAYLOAD COULD BE RETRIEVED WHILE IN FREE DRIFT MODE & IN SOME INSTANCES PAYLOAD MAY HAVE ATTITUDE & TRANSLATION CONTROL. IT MAY BE [illegible] TO USE FWD & AFT RCS (X AXIS) ENGINES FOR PITCH (DOWNWARD)

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :VERNIER THRUSTER
P/N RI :MC467-0029
P/N VENDOR:
QUANTITY :4
:2 PER POD
:1 PITCH, 1 YAW

FMEA NO 03-2A -231310-2 REV:11/03/78
ABORT: CRIT. FUNC: 2
CRIT. HDW: 2
MISSIONS: NF VF X FF OF SM
PHASE(S): PL LO CO X DO LS

REDUNDANCY SCREEN: A-PASS B-PASS C-FAIL

PREPARED BY:
DES J TAGGART
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY (NASA):
SSM
REL

DELETE
See Section 13.0

ITEM: THRUSTER, ASSY, VERNIER
25 POUND THRUST LEVEL. EN 357/358/257/258.

FUNCTION:
ONE PITCH (2 AXIS-UP FIRING) AND ONE YAW (PLUS/MINUS Y AXIS) VERNIER THRUSTER ARE PROVIDED IN EACH AFCS MODULE TO PROVIDE PRECISE LOW LEVEL PULSING AND ATTITUDE HOLD REQ'D FOR PAYLOAD POINTING. THEY ARE CONCEPTUALLY SIMILAR TO THE PRIMARY THRUSTER SOFT LIMIT PLUME IMPINGEMENT AND PROP RESIDUE CONTAM TO THE PAYLOAD.

FAILURE MODE: FAILS TO STOP (F)
FAILS OPEN, FAILS TO CLOSE (THRUSTER CONTINUES FIRING).

CAUSE(S):
CONTAMINATION, STRUCTURAL FAILURE, DUAL SHORT IN DRIVER CIRCUIT OR DUAL MDM FIRE COMMAND, VIB, SHOCK SEAL SEAT DAM, PROP RESIDUE, FLUSH SALTS, CORROS, WEAR.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION (VERNIER THRUSTERS) - CURRENTLY LOSS OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL. (B) DEGRADATION OF INTERFACE SUB-SYSTEM - PROP LOSS DUE TO EXCESS BURN-TIME UNTIL MANIFOLD CAN BE ISOLATED-POSS DAMAGE TO PAYLOAD OR PAYLOAD BAY ARMS. (C) MISSION MODIFICATION OR ABORT DECISION. (D) NO EFFECT.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) ISOLATION CAPABILITY IS AN AUTOMATIC FUNCTION WHICH WILL MINIMIZE FAILURE EFFECT. POSS REDUND MODES OF OPERATION. (PRIMARY THRUSTERS, FREE DRIFT MODE & PAYLOAD ATTITUDE CONTROL MAY PROVIDE ADDITIONAL CONTROL POTENTIAL). 100 MICRON FILTRATION PROVIDED. INADVERTENT FIRE SIGNAL IS IMPROBABLE DUE TO GPC/MDM DESIGN. (B) THRUSTER QUAL FOR 500,000 CYCLES, 125,000 SEC BURN TIME, INLET VALVE TESTED FOR 500,000 WET CYCLES & 5000 DRY. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 9-2-76. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND - SYSTEM FLUIDS ARE ANALYSED FOR EVIDENCE OF CONTAMINATION. PROPER INLET VALVE FUNCTION AND ELECTRICAL LOGIC POWER IS VERIFIED. (D) NO DIRECT FAILURE HISTORY AVAILABLE.

SUBSYSTEM AFT - RCS FMEA NUMBER 03-2A-231310-3

ITEM Vernier Thruster FAILURE MODE Burn Thru

1.	DOES THE FLIGHT SOFTWARE DETECT THIS FAILURE MODE (i.e., AUTOMATICALLY ANNUNCIATE OR TAKE ACTION IN RESPONSE)?	YES [X] NO [ ]
1a.	IF NOT, DOES THE HARDWARE PROVIDE INFORMATION THAT THE FLIGHT SOFTWARE COULD USE TO DETECT THE FAILURE?	*YES [X] NO [ ]
2.	ARE THE ANSWERS TO QUESTIONS 1 AND 1a CONSISTENT WITH THE FMEA EVALUATION OF IN-FLIGHT DETECTABILITY?	YES [ ] *NO [X]
3.	DOES THE FLIGHT SOFTWARE TAKE ACTION TO NEGATE THE EFFECTS OF THE FAILURE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	YES [X] NO [ ]
3a.	IF NOT, DOES THE CAPABILITY EXIST FOR THE SOFTWARE TO COMPENSATE FOR THIS FAILURE MODE (EITHER BY COMMANDING HARDWARE ACTION OR IMPLEMENTING ALTERNATE PROGRAM LOGIC)?	*YES [X] NO [ ]
4.	AS A RESULT OF THIS FAILURE MODE, CAN THE SOFTWARE OVERSTRESS THE HARDWARE OR INDUCE ANOTHER FAILURE?	*YES [ ] NO [X]
5.	CAN THIS FAILURE MODE, IN COMBINATION WITH SOFTWARE LOGIC, ADVERSELY AFFECT OTHER FUNCTIONS?	*YES [ ] NO [X]
6.	HOW MANY OF THESE HARDWARE FAILURES CAN THE SHUTTLE TOLERATE (CONSIDER CREW ACTION AND HARDWARE/SOFTWARE OPERATION)? NOTE CHANGE TO FMEA CRITICALITY.	*0 [X] *1 [ ] 2 [ ]
7.	IF CREW ACTION IS REQUIRED TO RESPOND TO THIS FAILURE MODE, ARE CUES PROVIDED TO SIGNAL THE NEED FOR INTERVENTION AND THE REQUIRED CORRECTIVE ACTION?	N/A [ ] YES [X] NO [ ]
8.	IF THE ANSWER TO EITHER 1 OR 3 IS YES:	
	A. CAN THE BFS BE ENGAGED AFTER OCCURRENCE?	YES [X] *NO [ ]
	B. WILL BFS TOLERATE FAILURE WITHOUT LOSS OF CREW/VEHICLE?	YES [X] *NO [ ]

*EXPLANATION REQUIRED (SEE BELOW)

CHANGE/RETENTION RATIONALE SUMMARY

1. [ ] NO H/S ISSUES	3. [ ] NO SOFTWARE DETECTION	5. [ ] ACCEPTANCE RATIONALE BELOW
2. [X] HARDWARE ACCEPTS RISK	4. [ ] DETECTION DURING CHECKOUT	6. [ ] RECOMMENDED CHANGES BELOW

[ ] FMEA CHANGE RECOMMENDED

EXPLANATION/COMMENTS:

1. "Failed off" thruster C&W.

3. Down modes to free drift.

6. No redundancy in the verniers.

SHUTTLE FAILURE MODE AND EFFECTS ANALYSIS - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :VERNIER THRUSTER
P/N PI :MC467-0029
P/N VENDOR:
QUANTITY :4
:2 PER POD
:1 PITCH, 1 YAW

FMEA NO 03-2A -231310-3 REV:11/08/7
ABORT: CRIT. FUNC: 1
CRIT. HWD: 1
MISSIONS: HF VF X HF OF SM
PHASE(S): PL LO X OO X DO X LS
NUMBER OF SUCCESS PATHS REMAINING
AFTER FIRST FAILURE: 2
REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

FAILURE DETECTABLE IN FLIGHT?. YES
CHAMBER PRESSURE ON EACH ENGINE, V42P82521 THRU V42P-2534 AND V42P-3521 THRU V42P-3534

GROUND TURNAROUND?.....YES
VISUAL INSPECITON

TIME TO EFFECT:
SECONDS
REFERENCE DOCUMENTS:
MC 621-0059
MJ070-0001-01B
SD72-SH-0103-2
VS70-421001

PREPARED BY:
DES J. TAGGART
REL C M AKERS

APPROVED BY:
DES _____
REL _____

ITEM: THRUSTER, ASSY, VERNIER
25 POUND THRUST LEVEL. EN 357/358/257/258.

FUNCTION:
ONE PITCH (2 AXIS-UP FIRING) AND ONE YAW (PLUS/MINUS Y AXIS) VERNIER THRUSTER ARE PROVIDED IN EACH ARCS MODULE TO PROVIDE PRECISE LOW LEVEL PULSING AND ATTITUDE HOLD REQ'D FOR PAYLOAD POINTING. THLY ARE CONCEPTUALLY SIMILAR TO THE PRIMARY THRUSTER BUT LIMIT PLUME IMPINGEMENT AND PROP RESIDUE CONTAM TO THE PAYLOAD.

FAILURE MODE: STRUCTURAL FAILURE (S)
BURN THRU OR RUPTURE IN CHAMBER.

CAUSE(S):
THERMAL CYCLING/STRESS FATIGUE, VIB, COMB INSTAB, SHOCK. BLOCKED INJ ORIFICES; HIGH TEMP/LOCALIZED HOT SPOTS/INADEQ COOLING NOZZLE RESTRICTION.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION-CURRENTLY LOSS OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL. (B) DEGRADATION OF INTERFACE FUNCTION-INCR GN&C & USE OF ALT THRUSTERS (C) MISSION MODIFICATION/ABORT DECISION IF FAILURE CAUSES DAMGE PROPAGATION. (D) POSSIBLE LOSS OF CREW/VEHICLE-BURN-THRU MAY CAUSE HIGH TEMP DAMAGE TO SUPR STRUCT & ADJ THRUSTERS RESULTING IN POSS ENTRY HAZ IF TPS IS DAMAGED.

CORRECTING ACTION:
ISOLATE PROPELLANTS FROM THRUSTER (AT MANIFOLD LEVEL) AND ASSESS FOR LEAKAGE AND DAMAGE TO SURROUNDING STRUCTURE.

REMARKS/HAZARDS:
THERE IS NO AUTO THRUSTER ISOL AFTER BURN INITIATION (DURING FIRING). HOT IMPINGMT OF HOT GASES ON MODULE STRUCT & ADJ THRUSTERS. BURN-THRU MAY CAUSE HIGH TEMP DAM TO SURR STRUCT & ADJ THRUSTERS RESULTING IN POSS ENTRY HAZ IF TPS IS DAMAGED.

SHUTTLE CRITICAL ITEMS LIST - ORBITER 102

SUBSYSTEM :AFT - REACTION CONTROL
ASSEMBLY :VERNIER THRUSTER
P/N RI :MC467-0029
P/N VENDOR:
QUANTITY :4
:2 PER POD
:1 PITCH, 1 YAW

FMEA NO 03-2A -231310-3 REV:11/08/78
ABORT: CRIT. FUNC: 1
CRIT. HDW: 1
MISSIONS: HF VF X FF OF SM
PHASE(S): PL LO X CO X DO X LS

REDUNDANCY SCREEN: A-N/A B-N/A C-N/A

PREPARED BY:
DES J TAGGART
REL C M AKERS

APPROVED BY:
DES
REL

APPROVED BY (NASA):
SSM
PE

APPROVED WITH CHANGES
See Section 13.0

ITEM: THRUSTER, ASSY, VERNIER
25 POUND THRUST LEVEL. EN 357/358/257/258.

FUNCTION:
ONE PITCH (2 AXIS-UP FIRING) AND ONE YAW (PLUS/MINUS Y AXIS) VERNIER THRUSTER ARE PROVIDED IN EACH APCS MODULE TO PROVIDE PRECISE LOW LEVEL PULSING AND ATTITUDE HOLD REQ'D FOR PAYLOAD POINTING. THEY ARE CONCEPTUALLY SIMILAR TO THE PRIMARY THRUSTER BUT LIMIT PLUME IMPINGEMENT AND PROP RESIDUE CONTAM TO THE PAYLOAD.

FAILURE MODE: STRUCTURAL FAILURE (S)
BURN THRU OR RUPTURE IN CHAMBER.

CAUSE(S):
THERMAL CYCLING/STRESS FATIGUE, VIB, COMB INSTAB, SHOCK. BLOCKED INJ ORIFICES, HIGH TEMP/LOCALIZED HOT SPOTS/INADEQ COOLING NOZZLE RESTRICTION.

EFFECT(S): ON (A)SUBSYSTEM (B)INTERFACES (C)MISSION (D)CREW/VEHICLE:
(A) LOSS OF FUNCTION-CURRENTLY LOSS OF SINGLE VERNIER THRUSTER CAUSES LOSS (SHUTDOWN) OF VERNIER CONTROL. (B) DEGRADATION OF INTERFACE FUNCTION-INCR GN&C & USE OF ALT THRUSTERS (C) MISSION MODIFICATION/ABORT DECISION IF FAILURE CAUSES DAMGE PROPAGATION. (D) POSSIBLE LOSS OF CREW/VEHICLE-BURN-THRU MAY CAUSE HIGH TEMP DAMAGE TO SURR STRUCT & ADJ THRUSTERS RESULTING IN POSS ENTRY HAZ IF TPS IS DAMAGED.

DISPOSITION & RATIONALE (A)DESIGN (B)TEST (C)INSPECTION (D)FAILURE HISTORY:
(A) STRUCTURAL MARGINS (2.0 TO 4.0) MINIMIZE FAILURE EFFECT(S). POSS REDUND MODES IN X AXIS PRIMARY THRUSTER, PAYLOAD ATTITUDE CONTROL & FREE DRIFT MODES. 100 MICRON FILTRATION & HEATERS PROVIDED TO LIMIT CONTAM & PREVENT PROP FREEZING. (B) THRUSTER QUAL FOR 500,000 CYCLES, 125,000 SEC BURN TIME, INLET VALVE TETED FOR 500,000 WET CYCLES & 5000 DRY. (C) A VISUAL INSP AND IDENTIFICATION IS PERFORMED AND THE UNIT TAGGED. CONTAMINATION CONTROL PROCESS, CORROS. PROTECTION PROVISIONS, NDE EXAM OF WELDS, RAW MAT'L (LOT) CERTIFICATION, PARTS PROTECTION, COATING AND PLATING PROCESSES ARE VERIFIED BY INSPECTION. MANUF, INSTALLATION, AND ASSY OPERATIONS ARE VERIFIED BY SHOP TRAVELER, MANDATORY INSP POINTS. THE ABOVE ITEMS AND THE FOLLOWING ITEMS WERE VERIFIED BY AUDIT CONDUCTED 9-2-76. CONTAMINATION CONTROL PLAN, PROPERLY MONITORED HANDLING AND STORAGE ENVIRONMENT, SPECIAL MEASUREMENT STANDARDS AND EQUIP AND MAT'L AND EQUIP CONFORMANCE TO CONTRACT REQMTS. TURNAROUND - VISUAL INSP USING OPTICAL INSTRUMENTATION. SYSTEM FLUIDS ARE ANALYSED FOR EVIDENCE OF CONTAMINATION. PROPER INLET VALVE FUNCTION AND ELECTRICAL LOGIC POWER IS VERIFIED. (D) NO DIRECT FAILURE HISTORY AVAILABLE.

MEETING MINUTES

Review of JSC 14651, Hardware/Software Interaction Analysis Volume VIII, AFT Reaction Control System Part 2 of 2.

1. Telecon held between Boeing-Houston/Rockwell, Downey 11/5/79 12:30 PM to 2:00 PM.

2. Attendees	Organization	Phone
Lonnie Jenkins	NASA/JSC	X 3851
Dave Latham	Boeing/Reliability	527-0323 (FTS)
Don Cagle	Boeing Reliability	527-0323 (FTS)
Herb Saxton	Rockwell Propulsion/RCS	X 4503
Larry Gladu	Rockwell Systems Engineering	X 1189

3. The following changes were discussed and will be incorporated in the final release of AFT Reaction Control System Hardware/Software Interaction Analysis and will be reflected in the next update of AFT RCS FMEA.

03-2A-201010-1: Change SM to RM GAX, change 400 psi to 500. Add gross leak detection. Add crossfeed.

03-2A-201013-1: No. 1 same as 201010-1. Add crossfeed. Add gross leak detection.

03-2A0201020-1: Change question 1 to ullage transducer will give C&W alert < 200 psi. Change no to yes.

03-2A-201030-2: Question 1 same as 201020-1

03-2A-201035-1: Question 1 same as 201020-1. Add gross leak detection.

03-2A-201060-4: Change question 1 no to yes and "No Software Detection" to "Hardware Accepts Risk". Add gross leak detection.

03-2A-201070-1: Change question 1 and 2 to gross leak detection. Add POD Redundancy to question 6.

03-2A-201080-1: Change question 1 to gross leak detection. Change question 6 from 2 to 0 and add "Need minimum of 2 yaw thrusters. Crossfeed is available. Pods are redundant.

03-2A-201090-1: Change question 1 to gross leak detection. Add question 6 - Pod redundancy.

03-2A-201095-2: Change question 6 from 1 to 2 and delete comments.

03-2A-202108-1: Change question 1 to gross leak detection. Delete question 7.

03-2A-202109-1: Delete questions 1, 3a and 6.

03-2A-202110-1: Change question 1 to - First indication "failed off" thruster C&W for 1/2 leg, redundant paths on 3,4,5 leg.

03-2A-202111-2: Question 1 change no to yes. Add "failed off" thruster gives first indication.

03-2A-202120-3: Change question 1 from yes to no and delete comments. Change question 3 from no to yes and add "RCS RM automatically detects and prevents thrusting".

03-2A-202150-1: Change question 1 to gross leak detection. Change question 6 from 0 to 1 and add "There is one success path remaining after first failure.

03-2A-211110-1: Change question 1 to gross leak detection. Change question 6 to POD Redundancy

03-2A-211110-2: Delete 1a/3a add question 1 "failed off" thruster may illuminate if < 40 psi is sensed 3 times, 80 milliseconds apart. Change no to yes. Question 2 change yes to no. Change question 3a from yes to no. Change question 6 from 0 to 1. Add crossfeed.

03-2A-211120-1: Change question 1 to-gross leak detection. Change question 6 from 0 to 1. Add crossfeed.

03-2A-221308-1: Change question 1 to gross leak detection. Delete comments question 2. Delete comments question 3 and change yes to no.

03-2A-221310-4: Delete 1a/3a, add question 1 "failed off" thruster C&W. Change no to yes. Question 3 change no to yes.

03-2A-221311-1: Same as 221310-4.

03-2A-221312-1: Same as 221310-4.

03-2A-221313-1: Question 1a change yes to no. Question 3a change yes to no.

03-2A-231310-1: Change no to yes, question 1 change no to yes, question 3 and add "down modes to free drift". Change yes to no, question 3a. Question 6 change 2 to 0 and add "No redundancy in the verniers".

03-2A-231310-2: Question 1 change no to yes, add "failed on" thruster C&W. Question 3a change yes to no. Question 6 change 2 to 0 and add "down modes to free drift."

03-2A-231310-3: Question 1 change no to yes. Change comments to "failed off" thruster C&W. Question 2, delete comments. Question 3, change no to yes and add "down modes to free drift". Question 6 change 2 to 0 and add "No redundancy in the verniers."

Approved by:

Larry Gladu 11/29/79
Larry Gladu, RI
System Engineering

Lonnie Jenkins 12/4/79
Lonnie Jenkins
JSC Propulsion

Dave Latham
Dave Latham
JSC Reliability (Boeing)

Don Cagle
Don Cagle
JSC Reliability (Boeing)

Document Number: JSC 14651

Title: HARDWARE/SOFTWARE INTERACTION ANALYSIS
Volume VIII, AFT Reaction Control System, Part 2 of 2

Prepared by: NB - Reliability Division

Distributed by: NB - SR&QA Data Center

Authorized Distribution

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