INDEPENDENT ORBITER ASSESSMENT

ASSESSMENT OF THE ELECTRICAL POWER GENERATION/FUEL CELL POWERPLANT SUBSYSTEM FMEA/CIL

20 MARCH 1987

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MCDONNELL DOUGLAS ASTRONAUTICS COMPANY HOUSTON DIVISION

SPACE TRANSPORTATION SYSTEM ENGINEERING AND OPERATIONS SUPPORT

WORKING PAPER NO. 1.0-WP-VA86001-24

INDEPENDENT ORBITER ASSESSMENT ASSESSMENT OF THE ELECTRICAL POWER GENERATION/FUEL CELL POWERPLANT SUBSYSTEM FMEA/CIL

20 March 1987

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Independent Orbiter Assessment Assessment of the Electrical Power Generation/Fuel Cell Powerplant Subsystem FMEA/CIL

1.0 EXECUTIVE SUMMARY

The McDonnell Douglas Astronautics Company (MDAC) was selected in June 1986 to perform an Independent Orbiter Assessment (IOA) of the Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL). Direction was given by the STS Orbiter and GFE Projects Office to perform the hardware analysis using the instructions and ground rules defined in <u>NSTS 22206</u>, <u>Instructions</u> for Preparation of FMEA and CIL, 10 October 1986.

The IOA effort first completed an analysis of the Electrical Power Generation/Fuel Cell Powerplant (EPG/FCP) hardware, generating draft failure modes and potential critical items. To preserve independence, this analysis was accomplished without reliance upon the results contained within the NASA FMEA/CIL documentation. The IOA results were then compared to the proposed Post 51-L NASA FMEA/CIL baseline. A resolution of each discrepancy from the comparison was provided through additional analysis as required. This report documents the results of that comparison for the Orbiter EPG/FCP hardware.

The IOA product for the EPG/FCP independent analysis consisted of sixty-two failure mode "worksheets" that resulted in thirty-two potential critical items being identified. A comparison was made of the IOA product to the NASA FMEA/CIL baseline dated 15 December 1986 which consisted of forty-three FMEAs and twenty-The difference in the number of IOA analysis three CIL items. worksheets and NASA FMEAs can be explained by the different levels of analysis detail performed to identify failure modes. The comparison determined if there were any results found by the IOA that were not included in the NASA baseline. The IOA analysis had identified seven failure modes, one of which was a CIL item, for components not covered by the NASA FMEAs. It was recommended that these failure modes be added to the NASA FMEA baseline. After discussions with the NASA subsystem manager on 13 March 1987, the IOA recommended failure modes and criticalities were agreed upon and added to the NASA proposed changes of the FMEA/CIL baseline. Figure 1 presents a comparison of the proposed Post 51-L NASA baseline with the IOA recommended baseline and any issues.

EPG/FCP ASSESSMENT OVERVIEW

~	**NO	ISSUES	0	0	
AMAR	SOLUTI	NASA	20	24	
r sur	IAL RE	Ø	50	24	
SSMEN	E		FMEA	CIL	
PASE	MENT *	ISSUES	7	—	_
G/FCI	VSSESSE	NASA	43	23	
ЕР	INAL /	POA	50	24	
	ORIG		FMEA	CIL	
		_	<u>.</u>	<u> </u>	



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Figure 1 - EPG/FCP FMEA/CIL ASSESSMENT

2.0 INTRODUCTION

2.1 Purpose

The 51-L Challenger accident prompted the NASA to readdress safety policies, concepts, and rationale being used in the National Space Transportation System (NSTS). The NSTS Office has undertaken the task of reevaluating the FMEA/CIL for the Space Shuttle design. The MDAC is providing an independent assessment of the proposed Post 51-L Orbiter FMEA/CIL for completeness and technical accuracy.

2.2 Scope

The scope of the independent FMEA/CIL assessment activity encompasses those Shuttle Orbiter subsystems and GFE hardware identified in the Space Shuttle Independent FMEA/CIL Assessment Contractor Statement of Work. Each subsystem analysis addresses hardware, functions, internal and external interfaces, and operational requirements for all mission phases.

2.3 Analysis Approach

The independent analysis approach is a top-down analysis utilizing as-built drawings to breakdown the respective subsystem into components and low-level hardware items. Each hardware item is evaluated for failure mode, effects, and criticality. These data are documented in the respective subsystem analysis report, and are used to assess the proposed Post 51-L NASA and Prime Contractor FMEA/CIL. The IOA analysis approach is summarized in the following Steps 1.0 through 3.0. Step 4.0 summarizes the assessment of the NASA and Prime Contractor FMEA/CIL which is documented in this report.

Step 1.0 Subsystem Familiarization

- 1.1 Define subsystem functions
- 1.2 Define subsystem components
- 1.3 Define subsystem specific ground rules and assumptions

Step 2.0 Define subsystem analysis diagram

- 2.1 Define subsystem
- 2.2 Define major assemblies
- 2.3 Develop detailed subsystem representations

Step 3.0 Failure events definition

- 3.1 Construct matrix of failure modes
- 3.2 Document IOA analysis results

Step 4.0 Compare IOA analysis data to NASA FMEA/CIL

- 4.1 Resolve differences
- 4.2 Review in-house
- 4.3 Document assessment issues
- 4.4 Forward findings to Project Manager

2.4 Ground Rules and Assumptions

The ground rules and assumptions used in the IOA are defined in Appendix B.

3.0 SUBSYSTEM DESCRIPTION

3.1 Design and Function

The EPG/FCP consists of hardware that is required for electrical power generation and Fuel Cell (FC) product water collection and distribution in the Orbiter. Reference Figures 2 and 3. The EPG/FCP consists of the following divisions:

- 1. The Power Section Assembly (PSA) which is also called Cell Stack Assembly (CSA) combines hydrogen and oxygen through an electrochemical conversion to produce electrical power, water, and heat. Each PSA cell stack consists of cell plates, pressure plates, end cell heater/insulator plates, tie rods, and individual cell voltage harness. Each cell plate is made up of Unitized Electrode Assembly (UEA) and separator plates. The cell stack consists of 96 cell plates grouped electrically into three substacks connected in parallel. The substack contains 32 cell plates connected electrically in series. The PSA also contains a cell performance monitor which provides continuous analog data outputs to the Orbiter. The outputs transmit individual cell performance problems or imminent failures. Reference Figure 4.
- 2. The Reactant Control Subsystem (RCS) consists of preheaters, coupled reactant regulator, hydrogen pumpseparator, condenser, hydrogen/water purge/vent line and oxygen purge/vent line. The RCS heats cryogenictemperature gaseous reactants (oxygen and hydrogen) from the Power Reactant Storage and Distribution System (PRSDS) to an acceptable temperature for delivery to the coupled reactant regulator. The RCS delivers reactant gases to the PSA on demand and controls the reactant pressure within the cell plates. The RCS provides for purging of inert gases from reactant lines. The RCS circulates hydrogen for water removal from the PSA and also prevents water from entering the PSA. Reference Figure 5.
- 3. The Thermal Control System (TCS) contains a coolant pump, thermal control valve, coolant accumulator, start/sustaining heater, and condenser. The TCS controls the FCP operating temperatures and electrolyte concentration. The TCS removes waste heat from the PSA and heat from the moist hydrogen recycle flow to condense water vapor. The TCS transfers heat to the inlet reactant gases passing through preheaters and rejects heat to the Orbiter vehicle cooling system. Reference Figure 6.
- 4. The Water Removal Subsystem (WRS) consists of a condenser, hydrogen pump-separator, water purity sensor, water trap and water discharge line. The WRS removes





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Figure 3 - FCP SUBSYSTEM OVERVIEW

FCP POWER SECTION ASSEMBLY

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Figure 4 - FCP POWER SECTION ASSEMBLY (PSA)

FCP REACTANT CONTROL SUBSYSTEM



Figure 5 - FCP REACTANT CONTROL SUBSYSTEM (RCS)







water produced in the PSA during the FCP operation. The FCP produces water vapor which is converted to a liquid in the condenser. The hydrogen pump-separator centrifugally separates the water from the hydrogen. The WRS delivers the water to the Orbiter vehicle potable water storage system or to the water relief line. Reference Figure 7.

3.2 Interfaces and Locations

The three EPG/FCPs are installed in the midbody of the Orbiter beneath the payload bay liner. Fuel Cell 1 (FC1) is located on the left-hand side of the payload bay. Whereas, FC2 and FC3 are located forward and aft respectively, on the right-hand side of the payload bay. Reference Figure 8. The FCPs PSA receives the hydrogen and oxygen reactants from the Power Reactants Storage and Distribution System (PRSDS). The product water from the PSA is transported to the Environmental Control and Life Support System (ECLSS) for storage. The waste heat produced by the PSA is rejected to the Orbiter vehicle cooling system through the FC40 coolant in the TCS. The FCP receives three-phase ac electrical power from the Orbiter to power the coolant pump, hydrogen pump-separator, and the water purity sensor. The FCP generates dc electrical power which is distributed to the Orbiter electrical power system. Reference Figure 9.

3.3 Hierarchy

Figures 2 and 3 illustrate the hierarchy of the EPG and FCP systems, respectively. The FCP subsystems are depicted in Figures 4 through 7.

FCP WATER REMOVAL SUBSYSTEM



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Figure 7 - FCP WATER REMOVAL SUBSYSTEM (WRS)





- O Three Orbiter FCP's installed in the Orbiter vehicle mid body beneath the payload liner
- FC1 installed on left-hand side
- FC2 installed forward on right-hand side
 - FC3 installed aft on right-hand side

FCP LOCATION AND INTERFACES



Figure 9 - FCP LOCATION AND INTERFACES

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4.0 ASSESSMENT RESULTS

The IOA analysis of the EPG/FCP hardware initially generated sixty-two failure mode worksheets and identified thirty-two Potential Critical Items (PCIs) before starting the assessment process. In order to facilitate comparison, five additional These analysis failure mode analysis worksheets were generated. results were compared to the proposed NASA Post 51-L baseline (22 May 1986) of forty-six FMEAs and twenty-two CIL items and to the updated (22 December 1987) version of forty-three FMEAs and twenty-three CIL items. The discrepancy between the number of IOA and NASA FMEAs can be explained by the different approach used by NASA and IOA to group failure modes. Upon completion of the assessment, and after a discussion with the NASA subsystem manager, an agreement between the NASA FMEAs and IOA failure modes was reached. Seven failure modes were generated by the IOA analysis that were not covered by the NASA FMEAs. The IOA recommended the addition of these failure modes to the NASA FMEA baseline. After discussions with the NASA subsystem manager the failure modes and criticalities were accepted and added to the NASA FMEA baseline.

In the analysis report, the FCP was divided into four sections according to hardware and function. However, in the assessment report the FCP has been divided into the four original sections plus a new section called FCP system (FCPS). The FCPS contains hardware from all four of the original sections. This new section was generated in order to facilitate comparison to the NASA FMEAS.

In the following, the unmapped IOA column is the raw number of IOA failure modes. The mapped IOA column is the number of IOA failure modes after they have been mapped into the NASA FMEAS. The issues column is the IOA failure modes that were unable to be mapped onto NASA FMEAS.

EPG/FCP Sections	IOA <u>Unmapped</u>	IOA Mapped	NASA	ISSUES
PSA	4	4	3	1
RCS	16	13	13	-
TCS	7	7	2	5
WRS	23	22	22	1
FCPS	<u>12</u>	_3	3	· · <u>-</u>
Total	62	50	43	7

Appendix C presents the detailed assessment worksheets for each failure mode identified and assessed. Appendix D highlights the NASA Critical Items and corresponding IOA worksheet ID. Appendix E contains IOA analysis worksheets supplementing previous analysis results reported in Space Transportation System Engineering and Operations Support (STSEOS) Working Paper No. 1.0-WP-VA86001-10, Analysis of the EPG/FCP, 05 December 1986. Appendix F provides a cross reference between the NASA FMEA and corresponding IOA worksheet(s). IOA recommendations are also summarized.

A summary of the quantity of NASA FMEAs assessed, versus the recommended IOA baseline, and any issues identified is presented in Table I.

Table I Sur	nmary of IO	A FMEA Ass	essment
Component	NASA	IOA	Issues
PSA RCS TCS WRS FCPS	3 13 2 22 3	4 13 7 23 3	1 - 5 1 -
TOTAL	43	50	7

A summary of the quantity of NASA CIL items assessed, versus the recommended IOA baseline, and any issues identified is presented in Table II.

Table II Su	ummary of I	DA CIL Asse	essment
Component	NASA	IOA	Issues
PSA RCS TCS WRS FCPS	3 6 - 11 3	4 6 - 11 3	1 - - - -
TOTAL	23	24	1

Table III presents a summary of the IOA recommended failure criticalities for the Post 51-L FMEA baseline. Further discussion of each of these subdivisions and the applicable failure modes is provided in subsequent paragraphs.

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1	TABLE III Summ	nary of	E IOA Re	ecommei	nded Fa	ilure C	ritical	lities	
	Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL	
	PSA RCS TCS WRS FCPS	1 - - 1 1	3 6 - 7 2	- - 2 -	- 3 - 5 -	- - 1 -	- 4 7 7	4 13 7 23 3	
	TOTAL	3	18	2	8	1	18	50	+ +

Of the failure modes analyzed, twenty-four were determined to be critical items. A summary of the IOA recommended critical items is presented in Table IV.

TABLE IV	Summary	y of IO	A Reco	mmended	Critica	al Ite	ms
Criticality:	1/1	2/1R	2/2	3/1R	3/2R	3/3	TOTAL
PSA RCS TCS WRS FCPS	1 - 1 1	3 6 - 7 2	- - 2 -		- - - 1 -	- - - -	4 6 - 11 3
TOTAL	3	17	2	+	1		24

The scheme for assigning IOA assessment (Appendix C) and analysis (Appendix E) worksheet numbers is shown in Table V.

+	Table V IOA Worksheet Numbers
Component	IOA ID Number
PSA	FCP-101, FCP-105, FCP-107, FCP-109, FCP-110
RCS	FCP-111 TO FCP-116, FCP-118 TO FCP-127
TCS	FCP-128, FCP-129, FCP-134 TO FCP-137,
	FCP-166X TO FCP-167X
WRS	FCP-144 TO FCP-165, FCP-168X TO FCP-170X
FCPS	FCP-104, FCP-106, FCP-108, FCP-117, FCP-130
	TO FCP-133, FCP-138 TO FCP-143

4.1 PSA Assessment Results

The first assessment between the IOA failure modes and the Post 51-L NASA FMEA baseline produced two issues. The issues were failure modes on the separator plates (MDAC ID 109) and cell performance monitor (MDAC ID 110) that had no corresponding NASA FMEAs. The new NASA baseline (15 December 1986) did not include any new FMEAs to resolve the existing issues.

A meeting with the NASA subsystem manager was held on 5 January 1987 and all PSA issues were discussed. The IOA agreed with the NASA subsystem manager that reactant blockage of the separator plates was not a credible failure and decided to resolve the issue by canceling analysis worksheet MDAC ID 109. The NASA subsystem manager agreed with the IOA analysis that the fail on mode of the self-test output of the cell performance monitor was a viable failure mode. This failure mode (MDAC ID 110) was submitted to Rockwell for addition to the NASA FMEA/CIL baseline on 16 March 1987 as a criticality 2/1R.

4.2 RCS Assessment Results

The IOA analysis generated seventeen failure modes from the RCS components. The initial assessment between the RCS failure modes and the Post 51-L NASA FMEA/CIL baseline produced four issues. The four issues were the failure modes on the integrated dual-gas regulator (MDAC ID 112, 114 and 116) and the hydrogen/oxygen (H2/O2) flowmeters (MDAC ID 127) that had no corresponding NASA FMEAs. In the course of reviewing the updated FMEA/CIL list (15 December 1986), MDAC ID 112 and 114, for hydrogen and oxygen overpressurization respectively, were compared to NASA FMEA 04-1A-0101-8. The new version of FMEA 04-1A-0101-8 included updated information to allow comparison and resolve the two issues. The new NASA baseline did not include any new FMEAs to resolve the remaining two issues. The IOA agreed with the NASA subsystem manager that the effect of a purge failure of the integrated dualgas regulator was covered by EPD&C/FCP NASA FMEA 05-6M5-2088-1, and EPG/FCP FMEAs 04-1A-0104-1 and 04-1A-0105-1. The IOA also agreed with the NASA subsystem manager that the effect of erroneous output from the H2/O2 flowmeters was covered by EPD&C/FCP NASA FMEA 05-6MA-2012-1. The IOA decided to resolve the previous two issues by canceling failure modes MDAC ID 109 and 127. The assessment also produced the cancellation of two RCS failure modes, MDAC ID 124 and 126. The IOA agreed with NASA's results that a heater could not fail "on". One failure mode was transferred to the FCPS section.

4.3 TCS Assessment Results

During the initial assessment, eleven TCS failure modes were compared to the Post 51-L NASA FMEA/CIL baseline which produced seven issues. The seven issues were failure modes on the stack temperature sensors (MDAC ID 134-137), coolant-pressure switch (MDAC ID 133), start-up heater (MDAC ID 128) and the thermalcontrol valve (MDAC ID 141). The updated version (15 December 1986) of FMEA 04-1A-0101-2 included new information to allow comparison and resolution of the MDAC ID 141 issue, erroneous output of the thermal-control valve. The IOA recommended that failure modes for high and low output of the stack inlet and outlet temperature sensors and the fail open failure of the coolant pressure switch be added to the baseline of the NASA These five failure modes were agreed upon by the NASA FMEA. subsystem manager and were incorporated into the NASA FMEA baseline 16 March 1987. The IOA agreed with the NASA subsystem manager that the effect of a failed "off" start-up heater was covered by NASA FMEA 05-6MA-2035-4.

During the IOA analysis process, failure modes were not generated for two failures of the coolant return temperature sensor. Two NASA FMEAs were written on the coolant return temperature sensor for erroneous output and open or shorted sensor failures. During the IOA assessment, two analysis worksheets were developed to cover the two failure modes. The IOA analysis results agreed with the NASA FMEA findings.

The assessment also produced the cancellation of the failure mode MDAC ID 129. The IOA agreed with NASA's results that a heater could not fail "on". Failure modes MDAC 130, 131 and 132 were transferred to the FCPS section.

4.4 WRS Assessment Results

The IOA analysis produced twenty-six failure modes from the WRS components. The initial assessment between the WRS failure modes and the Post 51-L NASA FMEA/CIL baseline produced seven issues. The assessment also produced the cancellation of four WRS failure modes, MDAC ID 146, 156, 161 and 162. The IOA agreed with NASA's results that a heater could not fail "on". Four other failure modes were transferred to the FCPS section.

The IOA agreed with NASA FMEAs 04-1A-0138-1 and 04-1A-0106-2 which correspond with the IOA failure modes MDAC ID 155 and 163. The IOA analysis had not considered the water relief heaters as standby redundant systems. The NASA results had considered the WRS as standby redundant and had screen B as NA. The updated version (15 December 1986) of FMEA 04-1A-0101-3 included information to allow resolution of issues with MDAC ID 139, restricted flow of the water separator pump. This failure mode was transferred to the FCPS section. The NASA subsystem manager agreed with the IOA analysis (MDAC ID 144) that erroneous output of the pH sensor was a viable failure. This failure mode was recommended to Rockwell for addition to the NASA FMEA/CIL baseline. It was officially added to the baseline in February 1987.

The discussion with the NASA subsystem manager resulted in a decision to change the MDAC ID 149, 152, and 153 analysis results to agree with the NASA FMEAs 04-1A-0122-3, 04-1A-0119-3, and 04-1A-0119-2 respectively.

During the IOA analysis process, failure modes were not generated for two failures of the FCP product water-line. These were failures of the heater and a gross external leakage failure of the FCP water lines, fittings and components. The two heater failures were inadvertently turned on (FMEA 04-1A-0144-3) and turned on during FCP shutdown (FMEA 04-1A-0144-4). During the IOA assessment, two failure modes (MDAC ID 168X and 169X) were developed to cover the two heater failure modes. The updated FCP FMEA/CIL list did not include FMEA 04-1A-0144-3 which had been The NASA subsystem manager also agreed to delete FMEA deleted. 04-1A-0144-4 in agreement with the IOA analysis. Another failure mode (MDAC ID 170X) was generated for the gross external leakage failure of the water lines, fittings, and components. The IOA agreed with NASA's criticality of 1/1 for FMEA 04-1A-0137-1, but recommended an analysis be performed to validate that the failure is credible.

4.5 FCPS Assessment Results

Twelve failure modes were transferred to the FCPS section from the other four sections. The initial assessment between the FCPS worksheets and Post 51-L NASA FMEA/CIL baseline produced no issue.

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5.0 REFERENCES

Reference documentation available from NASA and Rockwell was used in the analysis. The documentation used included the following:

- 1. JSC-12820, PCN-1 STS Operational Flight Rules, 12-16-85
- V45 File III, Operations and Maintenance Requirements and Specification Document - Orbiter OMRSD - Electrical Power Generation/Power Reactant Storage and Distribution, 5-29-86
- 3. TD268, Shuttle Flight Operations Manual, Vol 2, EPS, 11-84
- JSC-12830, EGIL Console Procedure Handbook, Rev. C, 10-83
- 5. NSTS 22206, Instructions for Preparation of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL), 10 October 1986
- 6. 100-2G, Rockwell International Reliability Desk Instruction Flight Hardware FMEA and CIL, 1-31-84
- 7. Orbiter Fuel Cell Powerplant Review and Training Course, International Fuel Cells (IFC), 5-86
- JSC-18691, Flight Data File Malfunction Procedures, Rev. B, 10-10-85
- 9. JSC-18540, Flight Data File Entry Checklist, Rev. B, 3-17-86
- 10. JSC-18547, Flight Data File Ascent checklist, Rev. B, 5-28-85
- 11. JSC-18541, Flight Data File Orbit Operations Checklist, Rev. B, 5-22-85
- 12. M4001002, JSC Orbiter Full Problem Record Report, EPG Subsystem, 7-22-86.
- VS70-945099, Integrated System Schematic Electrical Power System (EPS) Orbiter Vehicles -099, 103, 104, 7-18-85
- 14. VS70-945102, Integrated System Schematic Orbiter OV-102 EPS, 9-19-84
- 15. Magnesium Plate Status Review and Proposed Investigations to Improve Reliability, IFC, 7-15-86

- 16. EPA Ban on Future Use of Asbestos Creates Serious Orbiter Fuel Cell Availability Problem, IFC, 7-16-86
- 17. Orbiter Fuel Cell Powerplant Improved Coolant Accumulator, IFC, 7-15-86
- Orbiter Fuel Cell Powerplant Improved Cell Performance Monitoring, IFC, 7-15-86
- 19. Review of IFC Product Improvement Recommendations and Problems and Concerns, (Orbiter Operational Program), IFC, 7-16-86
- 20. N2 Diagnostic Test Data Review (Comparison of CPM Data to Single Cell Data), IFC, 7-16-86

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- 21. Program Review Orbiter Operational Improvement Program, IFC, 7-15-86
- 22. Operational Program Powerplant(s) Failure Review, IFC, 7-15-86
- 23. Rockwell Specifications for Fuel Cells

a. b.	MC ME	464-0115 363-0042-0003	Fuel Cell Water Nozzle & Heater Assembly
c. d. e. f.	MC ME MC MC	284-0431-0001 284-0475-0001 363-0037-0001 363-0038-0014	Water Pressure Relief Valve Water Supply Check Valve Strip Heater EPG Line Heater H20 Relief Vent Line
g. h.	MC MC	363-0038-0001-0004 363-0038-0003-0004	Line Heater Oxygen Purge Line Line Heater Hydrogen Purge Line
i.	MC	363-0037-0002	Strip Heater Hydrogen Purge Port
j.	MC	363-0038-0006	Line Heater, FCP Product Water Line
k.	ME	449-0160-0003	Temperature Sensors for Product Water Line, Water Relief Valve, Coolant Return, Oxygen Vent Line, Hydrogen Vent Line and Water Relief Line

24. Rockwell International Drawings

a.	VS70-450-102	Orbiter Fuel Cell Control Subsyster
b.	VS70-450-109	Orbiter Fuel Cell Control Subsyster
c.	VS70-450-112	Orbiter Fuel Cell Control Subsyster
d.	VS70-450-119	Orbiter Fuel Cell Control Subsystem
e.	V070-454-765	Panel - Water Relief Assembly

25. Pratt and Whitney Aircraft Drawings

a.	752153	Plate - Fuel Electrode
b.	752154	Plate - Oxidizer Electrode
c.	752158	Plate - Oxidizer Electrode
d.	754930	Electrode - Fuel Cell Assembly
e.	755422	Plate - Fuel Electrode Terminal
f.	768429	Heater Coolant Start-up
q.	769016	Regulator, Reactant
ń.	769288	Accumulator and Strap Coolant Assembly
i.	769546	Filter Coolant (Ref Drawing 14336 501
		Change B)
1.	770488	Transducer - Oxidizer Flow
k.	770489-91	Transducer - Fuel Flow
1.	770598-99	Components Assembly - Fuel Cell
m.	782900	Power Plant Assembly - Fuel Cell
n.	787900	Power Plant Assembly - Fuel Cell
ο.	788400	Power Plant Assembly - Fuel Cell
p.	796798	Components Assembly - Fuel Cell
٩.	800634	Cable - Fuel Cell Output Assembly
r.	800635	Wiring Harness, Fuel Cell Input
s.	800636	Wiring Harness, Fuel Cell
t.	822998	Cable Routing - Component Assembly
u.	823098	Component Assembly - Fuel Cell
v.	823100	Power Plant Assembly - Fuel Cell

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- 29. NASA-JSC FMEAs and CIL, 12-15-86

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APPENDIX A ACRONYMS

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AOA	_	Abort-once-Around
ATO	-	Abort-to-Orbit
CIL	_	Critical Items List
CPM	_	Cell Performance Monitor
CRIT	-	Criticality
CSA	-	Cell Stack Assembly
C&W	_	Caution and Warning System
ECLSS	-	Environmental Control and Life Support System
EPA	-	Environmental Protection Agency
EPG	_	Electrical Power Generation
EPS	-	Electrical Power System
F	-	Functional
FC	-	Fuel Cell
FCP	-	Fuel Cell Powerplant
FCPS		Fuel Cell Powerplant System
FMEA	-	Failure Mode and Effect Analysis
FSSR	- .	Flight System Software Requirement
GFE	_	Government Furnished Equipment
HW	_	Hardware
IFC	_	International Fuel Cells
IOA	_	Independent Orbiter Assessment
MDAC	_	McDonnell Douglas Astronautics Company
NASA	-	National Aeronautics and Space Administration
NSTS	_	National Space Transportation System
NA	-	Not Applicable
OMRSD	-	Operations and Maintenance Requirements and Specification
DOT		Document
PCI	-	Potential Critical Item Drogram Boggiromonta Control Board
PRCB	-	Program Requirements Control Board
PRODO	-	Power Reactant Storage & Distribution System
PSA	-	Power Section Assembry
RCS	-	Reactant control subsystem
	-	Rockwell International
RILS	-	Return to Launch Site
SM	-	System Management
515	-	Transatlantia Abort Landing
	-	Transactancic Abort Banding Thermal Control Subsystem
	-	Intrinal Concrete Jesembly
	-	Unitized Electiode Assembly
WKS	-	water Removar Subsystem

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APPENDIX B

DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.1 Definitions

- B.2 Project Level Ground Rules and AssumptionsB.3 Subsystem-Specific Ground Rules and Assumptions

APPENDIX B DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.1 Definitions

Definitions contained in <u>NSTS</u> 22206, <u>Instructions</u> For <u>Preparation</u> of <u>FMEA/CIL</u>, <u>10</u> October 1986</u>, were used with the following amplifications and additions.

INTACT ABORT DEFINITIONS:

<u>RTLS</u> - begins at transition to OPS 6 and ends at transition to OPS 9, post-flight

TAL - begins at declaration of the abort and ends at transition to OPS 9, post-flight

<u>AOA</u> - begins at declaration of the abort and ends at transition to OPS 9, post-flight

<u>ATO</u> - begins at declaration of the abort and ends at transition to OPS 9, post-flight

<u>CREDIBLE (CAUSE)</u> - an event that can be predicted or expected in anticipated operational environmental conditions. Excludes an event where multiple failures must first occur to result in environmental extremes

<u>CONTINGENCY</u> <u>CREW</u> <u>PROCEDURES</u> - procedures that are utilized beyond the standard malfunction procedures, pocket checklists, and cue cards

EARLY MISSION TERMINATION - termination of onorbit phase prior to planned end of mission

EFFECTS/RATIONALE - description of the case which generated the highest criticality

<u>HIGHEST CRITICALITY</u> - the highest functional criticality determined in the phase-by-phase analysis

<u>MAJOR</u> <u>MODE</u> (<u>MM</u>) - major sub-mode of software operational sequence (OPS)

 \underline{MC} - Memory Configuration of Primary Avionics Software System (PASS)

<u>MISSION</u> - assigned performance of a specific Orbiter flight with payload/objective accomplishments including orbit phasing and altitude (excludes secondary payloads such as GAS cans, middeck P/L, etc.) MULTIPLE ORDER FAILURE - describes the failure due to a single cause or event of all units which perform a necessary (critical) function

OFF-NOMINAL CREW PROCEDURES - procedures that are utilized beyond the standard malfunction procedures, pocket checklists, and cue cards

OPS - software operational sequence

PRIMARY MISSION OBJECTIVES - worst case primary mission objectives

PHASE DEFINITIONS:

<u>PRELAUNCH</u> <u>PHASE</u> - begins at launch count-down Orbiter power-up and ends at moding to OPS Major Mode 102 (liftoff)

LIFTOFF MISSION PHASE - begins at SRB ignition (MM 102) and ends at transition out of OPS 1 (Synonymous with ASCENT)

ONORBIT PHASE - begins at transition to OPS 2 or OPS 8 and ends at transition out of OPS 2 or OPS 8

DEORBIT PHASE - begins at transition to OPS Major Mode 301 and ends at first main landing gear touchdown

LANDING/SAFING PHASE - begins at first main gear touchdown and ends with the completion of post-landing safing operations

APPENDIX B DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

B.2 IOA Project Level Ground Rules and Assumptions

The philosophy embodied in <u>NSTS 22206</u>, <u>Instructions for</u> <u>Preparation of FMEA/CIL</u>, <u>10 October 1986</u>, was employed with the following amplifications and additions.

1. The operational flight software is an accurate implementation of the Flight System Software Requirements (FSSRs).

RATIONALE: Software verification is out-of-scope of this task.

 After liftoff, any parameter which is monitored by system management (SM) or which drives any part of the Caution and Warning System (C&W) will support passage of Redundancy Screen B for its corresponding hardware item.

> RATIONALE: Analysis of on-board parameter availability and/or the actual monitoring by the crew is beyond the scope of this task.

3. Any data employed with flight software is assumed to be functional for the specific vehicle and specific mission being flown.

RATIONALE: Mission data verification is out-of-scope of this task.

4. All hardware (including firmware) is manufactured and assembled to the design specifications/drawings.

RATIONALE: Acceptance and verification testing is designed to detect and identify problems before the item is approved for use.

5. All Flight Data File crew procedures will be assumed performed as written, and will not include human error in their performance.

RATIONALE: Failures caused by human operational error are out-of-scope of this task.
6. All hardware analyses will, as a minimum, be performed at the level of analysis existent within NASA/Prime Contractor Orbiter FMEA/CILs, and will be permitted to go to greater hardware detail levels but not lesser.

> RATIONALE: Comparison of IOA analysis results with other analyses requires that both analyses be performed to a comparable level of detail.

7. Verification that a telemetry parameter is actually monitored during AOS by ground-based personnel is not required.

RATIONALE: Analysis of mission-dependent telemetry availability and/or the actual monitoring of applicable data by ground-based personnel is beyond the scope of this task.

8. The determination of criticalities per phase is based on the worst case effect of a failure for the phase being analyzed. The failure can occur in the phase being analyzed or in any previous phase, whichever produces the worst case effects for the phase of interest.

RATIONALE: Assigning phase criticalities ensures a thorough and complete analysis.

9. Analysis of wire harnesses, cables, and electrical connectors to determine if FMEAs are warranted will not be performed nor FMEAs assessed.

RATIONALE: Analysis was substantially complete prior to NSTS 22206 ground rule redirection.

10. Analysis of welds or brazed joints that cannot be inspected will not be performed nor FMEAs assessed.

RATIONALE: Analysis was substantially complete prior to NSTS 22206 ground rule redirection.

11. Emergency system or hardware will include burst discs and will exclude the EMU Secondary Oxygen Pack (SOP), pressure relief valves and the landing gear pyrotechnics.

> RATIONALE: Clarify definition of emergency systems to ensure consistency throughout IOA project.

APPENDIX B

DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

- B.3 EPG-Specific Ground Rules and Assumptions
- 1. Component age life will not be considered in the analysis.

RATIONALE: Component age life analysis is beyond the scope of this task.

2. Cryogenic system pressure to the fuel cell will be assumed lost if unable to maintain minimum supply conditions of 100 PSI for H2 and/or O2 tanks.

RATIONALE: Minimum requirements definition. Flight rule definition.

3. An O2 cryo tank will be assumed lost if both of its heaters fail to function (i.e., neither heater will function with the delta current sensors enabled).

RATIONALE: Systems failure definition. Flight rule definition.

4. An H2 cryo tank will be assumed lost if neither of its heaters will function.

RATIONALE: Systems failure definition. Flight rule definition.

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5. An impending loss of all cryo O2 or all cryo H2 tanks will be cause to exercise the highest-priority abort mode the loss/leak will allow.

RATIONALE: Flight rule definition.

6. Continue nominal ascent if 2/3/4 O2 (H2) tanks fail when flying 3/4/5.

Enter next PLS daily go/no-go if two O2 (H2) tanks fail during lift-off and on-orbit.

RATIONALE: Flight rules go/no-go criteria.

7. Ascent abort decision will be needed for any EPG/PRSD/FCP problems that will not support four hours on-orbit plus entry time.

RATIONALE: Flight operations rules.

B-6

- 8. A fuel cell will be considered failed if the following conditions exist.
 - a. An abnormal or unexplained voltage versus current performance loss of >0.5 volts for a single FC based on predicted performance data.
 - b. Coolant pump or H2 pump/H2O separator is lost.
 - c. Fuel cell stack-coolant temperature >255 degrees (242.5) degrees F or <175 degrees (182.5) degrees F.</p>
 - d. Coolant pressure >75 (71.4) PSIA and increasing.
 - e. Fuel cell unable to discharge water to the ECLSS H20 storage tanks or overboard via the fuel cell H20 relief system.
 - f. Local KOH concentration >48 percent (45 percent) dry or <24 percent (29 percent) wet as indicated by fuel cell stack-coolant temperature, condenser exit temperature, and current relationship.
 - g. Fuel cell reactant valve fails closed.
 - h. Cannot be connected to a main bus.
 - i. Fuel cell H2O pH high confirmed.
 - j. Fuel cell O2 reaction chambers cannot be purged.
 - k. Fuel cell end-cell heater failing on.
 - Fuel cell substack delta volts >150 millivolts and increasing.

RATIONALE: Systems failure definition.

9. Loss of one fuel cell is considered cause for priority flight and abort decision.

RATIONALE: Mission flight rule definition.

10. Loss of two fuel cells is considered cause for abort mission.

RATIONALE: Contingency action summary. Flight Rule definition.

11. Loss of three fuel cells is considered loss of life/vehicle in all mission phases.

RATIONALE: Flight rule definition.

12. Loss of two fuel cells in the first stage of ascent is considered loss of life/vehicle.

RATIONALE: SRB loads are too high for one fuel cell to support. Voltage may go <25v which will shut down the GPCs.

- 13. Although the ECLSS product-water storage is a separate system from EPG, it will be considered as a failable redundant product-water relief line for purposes of the EPG functional criticality scenarios.
 - RATIONALE: This assumption violates general ground rule 2.3.2.d but is essential for evaluating failures associated with the water relief line.
- 14. Filter failure will only be considered in the case of total flow blockage. Cases of improper/insufficient filtering will not be considered except where obvious.
 - RATIONALE: The effect of 'poor' filter performance on downstream components is beyond the scope of our efforts.

- 15. The start/sustaining heater on the left-hand FCP (FCP #1) is assumed to be disconnected. Thus, this FCP cannot be maintained operational at no-load, and will be considered shutdown if the load cannot be maintained at greater than 2 KW.
 - RATIONALE: Load needed to maintain operating temperature. Right hand FCP uses sustaining heater to maintain temperature at no-load.
- 16. For all "failed open" failure modes for valves which are normally open, redundancy screen B will be assumed failed.

RATIONALE: The failure is not detectable until the valve is required to be closed.

17. Five 02 and H2 tanks are being used as the baseline configuration under study.

RATIONALE: The configuration for all redundant components is being considered for this analysis.

18. Inadvertent Fuel Cell shutdown during RTLS and TAL abort is considered loss of crew/vehicle.

RATIONALE: Loss of FCP 1/Bus A is loss of OMS Engine Purge Capability (required for TAL) and Aft Compartment MPS Helium Purge Capability (required for RTLS and TAL).

APPENDIX C DETAILED ASSESSMENT

This section contains the IOA assessment worksheets generated during the assessment of this subsystem. The information on these worksheets facilitates the comparison of the NASA FMEA/CIL (Pre and Post 51-L) to the IOA detailed analysis worksheets included in Appendix E. Each of these worksheets identifies the NASA FMEA being assessed, corresponding MDAC Analysis Worksheet ID (Appendix E), hardware item, criticality, redundancy screens, and recommendations. For each failure mode, the highest assessed hardware and functional criticality is compared and discrepancies noted as "N" in the compare row under the column where the discrepancy occurred.

LEGEND FOR IOA ASSESSMENT WORKSHEETS

Hardware Criticalities:

- 1 = Loss of life or vehicle
- 2 = Loss of mission or next failure of any redundant item
 - (like or unlike) could cause loss of life/vehicle
- 3 = All others

Functional Criticalities:

- 2R = Redundant hardware items (like or unlike) all of which, if failed, could cause loss of mission

Redundancy Screens A, B and C:

- P = Passed Screen
- F = Failed Screen
- NA = Not Applicable

NASA Data : Baseline

Baseline = NASA FMEA/CIL New = Baseline with Proposed Post 51-L Changes

CIL Item :

X = Included in CIL

Compare Row :

N = Non compare for that column (deviation)

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LEAD ANALYST:	M. HIOTT				
ASSESSMENT:					
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LEAD ANALYST:	M. HIOTT				
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THE NASA SUBSYSTEM MANAGER AGREED WITH THE IOA ANALYSIS FOR THIS COMPONENT AND WILL RECOMMEND THIS FAILURE MODE TO ROCKWELL FOR ADDITION TO THE NASA FMEA/CIL LIST.

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RECOMMEN	DATI	ONS:	(If	di	ff	ere	nt	fı	ro	m NA	SA)							
	[/]		[]		[]	[]	(AD	[D/	DI] SLF	ETE)
* CIL RE	TENT	ION F	LTAS	ONA	LE	:	(If	aj	ppl	. i	cabl	e) IN	AI IAI	DEQU DEOU	ATE ATE		[x]	
REMARKS:																•	L		7	

REPORT DATE 03/24/87 C-14

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-116	Y	IASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 116 INTEGRATED DUAL	GAS REGULAT	OR	
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH	ITY REDUNDA F	NCY SCREENS		CIL ITEM
HDW/FU	NC A	B C	2	
NASA [/ IOA [2/1R] []] [P]	[] [[P] [F)]	[] * [X]
COMPARE [N/N] [N]	[N] [N	[]	[И]
RECOMMENDATIONS:	(If different	from NASA)		
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* CIL RETENTION H	RATIONALE: (If ap	oplicable) A ATNA	DEQUATE	
REMARKS: THE FAILURE OF TH PERFORMANCE. THI 0101-8. AN ADDIT WOULD CAUSE REACT SHUTDOWN.	HE REGULATOR TO D S FAILURE IS THE CIONAL FAILURE RE CANT OVERPRESSUR	PURGE DEGRAD E OPPOSITE O ESULTING IN IZATION, WHI	ES THE FU F NASA FM THE NEED CH REQUIP	JEL CELL MEA 04-1A- TO VENT RES FUEL CELL

THE EFFECT FOR THIS ANALYSIS HAS BEEN COVERED BY NASA FMEAS 05-6MA-2088-1, 04-1A-0104-1 AND 04-1A-0105-1, THEREFORE, THE IOA ANALYSIS HAS BEEN CANCELLED.

ASSESSME ASSESSME NASA FME	NT NT A	DZ II #:	ATE: D:	11 FC 04	/28, P-1] -1A-	/8 L7 -0:	6 101-4	1				NASA DA BASELI N	TA: NE EW	[[x]	
SUBSYSTE MDAC ID: ITEM: COMPONEN	M: TS			EP 11 H2	G 7 /02	Ľ	INES	AND	FIT	TING	s i	AND ACCE	ssc	R	Y		
LEAD ANA	LYS	ST:		М.	HIC)T	r										
ASSESSME	NT	:															
	CRI	TI T	CAL	[TY			REDU	JNDAN	CY	SCRE	ENS	5		C:	EL EL	,	
	F	IDW	I/FUI	NC			A		В			с		τ.	, E. P	'L	
NASA IOA	[[1 1	/1 /1]] [NA] NA]	[[NA NA]	[NA] NA]		[[X X]]	*
COMPARE	[/]		[]	[]	[]		[]	
RECOMMEN	DA!	ric	ONS:		(If	d:	lffei	rent	fro	m NA	SA))					
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* CIL RET	ren	ITI	on f	RAT:	IONA	LE	: (I	f app	pli	cabl	e) IN	ADEQUAT IADEQUAT	E	[x]]	

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REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-118 04-1A-010	4-1		NASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 118 O2/H2 PUR	GE-VENT L	INES AND	VENT NOZ	LES
LEAD ANALYST:	M. HIOTT				
ASSESSMENT:					
CRITICAL FLIGH	ITY R T	EDUNDANCY	SCREENS	_	CIL ITEM
HDW/FU	NC A	В		С	
NASA [2 /1R IOA [2 /1R] [P] [P) [P) [P	·][][P] P]	[X] * [X]
COMPARE [/] [] [] []	[]
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* CIL RETENTION	RATIONALE:	(If appl	icable) IN	ADEQUATE ADEQUATE	[X]
REMARKS:				-	

REPORT DATE 03/24/87 C-17

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ASSESSN ASSESSN NASA FN	ient ient iea #	DATE: ID: #:	11/28, FCP-11 04-1A-	/86 18A -0105	5-1			1	NASA DAT BASELIN NE	'A: E [W [X]]
SUBSYST MDAC II ITEM:	YEM: D:		EPG 118 02/H2	PURG	E-VE	ENT L	INES 2	AND	VENT NO	ZZLES	
LEAD AN	IALYS	ST:	M. HIC	OTT							
ASSESSM	ENT:										
	CRI	TICAL	ITY r	RE	DUND	ANCY	SCREI	ENS		CIL ITEN	1
	H	IDW/FUI	NC	A		В		C	2		
NASA IOA		2 /1R 2 /1R]	[P [P]	[P [P]	[] []	?] ?]	[X [X] *]
COMPAR	È [/]	[]	[]	נ]	٢]
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	[/]	[]	[]	[]	[ADD/DI] ELETE)
* CIL F	ETEN	TION I	RATIONA	LE:	(If	appli	Lcabl	e) A INA	ADEQUATE	[X]
REMARKS	:									-	-

REPORT DATE 03/24/87 C-18

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-118B 04-1A-0107-1	NASA BASE	DATA: LINE [] NEW [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 118 02/H2 PURGE-VEN	NT LINES AND VENT	NOZZLES
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICAL FLIGH	ITY REDUNDA F	NCY SCREENS	CIL ITEM
HDW/FUI	NC A	B C	
NASA [2 /1R IOA [2 /1R] [P]] [P]	[P] [P] [P] [P]	[X]* [X]
COMPARE [/] []	נייני	[]]
RECOMMENDATIONS:	(If different	from NASA)	
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* CIL RETENTION H	RATIONALE: (If a	pplicable) ADEQU INADEQU	ATE [X] ATE []

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REMARKS:

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ASSESSME ASSESSME NASA FME	ENT I ENT I EA #:	DATE: ID: :	11/28 FPC-1 04-1A	/86 18C -010	8-1			1	IASA BASE	DATA LINE NEW	:]]	x]]	
SUBSYSTE MDAC ID: ITEM:	:M:		EPG 118 02/H2	PUR	GE-V	VENT I	INES	S AND	VENI	NOZ	ZLI	ES		. :
LEAD ANA	LYSI	C:	M. HIG	OTT										
ASSESSME	NT:													
	CRIT F	TICALI TLIGHT	CTY C	F	EDUN	IDANCY	SCF	REENS			C: I]	IL TEN	1	
	HI	W/FUN	1C	A		В	I.	C	:					
NASA IOA	[2 [2	2 /1R 2 /1R]	[F [F		[P [P]	[F [F)]]]	X X]]	*
COMPARE	[/]	[]	[]	[]		נ]	
RECOMMEN	IDAT:	IONS:	(If	dif	fere	ent fr	om N	IASA)						
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								INA	DEQU	ATE	[л]	

REMARKS:

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-119 04-1A-0131-1	NASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 119 O2 PURGE LINE TEMPERATU	RE SENSOR	
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICALI FLIGHT HDW/FUN	ITY REDUNDANCY SCRE F NC A B	ens C	CIL ITEM
NASA [3 /3 IOA [3 /3] [NA] [NA]] [NA] [NA]	[NA] [NA]	[]*
COMPARE [/] [] []	[]]	[]]
RECOMMENDATIONS:	(If different from NA	SA)	
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* CIL RETENTION F	ATIONALE: (If applicable)	e) ADEQUATE INADEQUATE	[]

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ASSESSME ASSESSME NASA FME	NT E NT I A #:	DATE: ID:	11/2 FCP- 04-1	28/86 -120 LA-013	1-2				NASA I BASEI	DATA INE NEW	: []	x]	
SUBSYSTE MDAC ID: ITEM:	M:		EPG 120 02 I	PURGE	LINE	TEM	PERAI	URE	SENSOR	2			
LEAD ANA	LYST	:	M. H	IIOTT									
ASSESSME	NT:												
(CRIT F HD	'ICAL 'LIGH W/FU	ITY T NC	R A	EDUN	IDANC	Y SCR B	EENS	s c		CI IT	L EM	
NASA IOA	[3 [3	/3 /3]]	[N. [N.	A] A]	[] []	NA] NA]	[[NA] NA]]]	*
COMPARE	[/]	[]	٢]	[]		[]	
RECOMMEN	DATI	ons:	(]	f dif	fere	ent fi	rom N	iasa)					
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REMARKS:

REPORT DATE 03/24/87 C-22

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-121 04-1A-0132-1	NASA DATA: BASELINE [] NEW [X]	
SUBSYSTEM: MDAC ID: ITEM:	EPG 121 H2 PURGE LINE TEMPERATU	RE SENSORS 1 & 2	
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICALI FLIGHT HDW/FUN	ITY REDUNDANCY SCREI F NC A B	ENS CIL ITEM C	
NASA [3 /3 IOA [3 /3] [NA] [NA]] [NA] [NA]	[NA] [] [*] [NA] []	*
COMPARE [/] [] []	[]]	
RECOMMENDATIONS:	(If different from NA	SA)	
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* CIL RETENTION F	RATIONALE: (If applicable	>) ADEQUATE [] INADEQUATE []	

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SUBSYSTEN MDAC ID: ITEM:	1:		EPG 122 H2 PUI	RGE 1	LINE	TEM	P. SE	NSOF	RS 1 & 2			
LEAD ANAI	LYST	:	M. HIC	DTT								
ASSESSMEN	1T :											
c	RIT	ICAL:	ETY r	RI	EDUNI	DANC	Y SCR	EENS	5	C T	IL TEM	
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	[/]	[]	۵]	[]] (ADD	/DE] LETE)
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REMARKS:										-		-

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-123 04-1A-0142-1	NASA DATA BASELINE NEW	: [x] [x]
SUBSYSTEM: MDAC ID: ITEM:	EPG 123 O2 PURGE LINE HEATERS (6	;)	
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICALI FLIGHT HDW/FUN	ITY REDUNDANCY SCREE F NC A B	NS C	CIL ITEM
NASA [3 /1R IOA [3 /1R] [P] [P]] [P] [P]	[P] [P]	.[]*
COMPARE [/] [] []	[]	[]
RECOMMENDATIONS:	(If different from NAS	A)	
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* CIL RETENTION F	RATIONALE: (If applicable) ADEQUATE INADEQUATE	[] []

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:				11 FC	11/28/86 FCP-124				NASA DATA: BASELINE [] NEW [X]								
SUBSYSTEM: MDAC ID: ITEM:				EP 12 02	EPG 124 O2 PURGE LINE HEATERS (6)												
LEAD ANALYST:			м.	M. HIOTT													
ASSESSME	NT :	:												-		1.5	· · · ·
CRITICALI				ITY	ITY REDUNDANCY SCRE					REEN	EENS			CIL			
	F	IDV	√FU	NC		A			в			C	:			11	
NASA IOA	[[3	/ /3]	[[NA	7]	[[NZ	7]]	[[N] [A]		[[] ;	ł
COMPARE	[N	/N]	[N]	[N]	[N]		Γ]	
RECOMMENDATIONS: (If different from NASA)																	
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* CIL RE	FEN	IT]	ON	rat:	IONALE	:	(11	Eap	pli	lcal	ble) I	A NA	DEQU DEQU	ATE ATE	Г Г]	
REMARKS: A HEATER CONTINUOU	CA US	NN PC	IOT WER	FAI: , A	L ON E SWITC	Y	ITS OR	SELF. THEI	, RMC	FOI	R A I AT M	HE. US	ATER ST FA	TO F	RECE	IVE ED.	THE

FAILURE OF A SWITCH OR THERMOSTAT HAS BEEN EVALUATED IN OTHER

NASA FMEAS. THE IOA ANALYSIS WORKSHEET 124 HAS BEEN CANCELLED.

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-125 04-1A-0143-1	NAS. BAS	A DATA: SELINE [] NEW [X]					
SUBSYSTEM: MDAC ID: ITEM:	EPG 125 H2 PURGE LINE	HEATERS (6) AND	NOZZLE HEATERS (2)					
LEAD ANALYST:	M. HIOTT							
ASSESSMENT:								
CRITICALI FLIGHT HDW/FUN	TY REDUND C A	ANCY SCREENS B C	CIL ITEM					
NASA [3 /1R IOA [3 /1R] [P]] [P]	[P] [P] [P] [P]	[]_* []					
COMPARE [/] []	[]][]]	[]					
RECOMMENDATIONS: (If different from NASA)								
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* CIL RETENTION F	ATIONALE: (If	applicable) ADE(INADE(QUATE [] QUATE []					

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-125B 04-1A-0149	9-1	NA Bi	SA DATA: ASELINE [NEW [X]			
SUBSYSTEM: MDAC ID: ITEM:	EPG 125 H2 PURGE	LINE HEAT	ERS (6) AN	D NOZZLE HI	EATERS (2)			
LEAD ANALYST:	M. HIOTT							
ASSESSMENT:								
CRITICALI FLIGHT HDW/FUN	ITY RI I IC A	EDUNDANCY B	SCREENS C	CIL ITE	M			
NASA [3 /1R IOA [3 /1R] [P]] [P] [P]] [P] [P]] [P]] [] [] *]			
COMPARE [/] [] [] [] []			
RECOMMENDATIONS: (If different from NASA)								
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* CIL RETENTION F REMARKS:	ATIONALE:	(If appli	cable) ADI INADI	EQUATE [EQUATE []			

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-126	NASA DATA BASELINE NEW	A DATA: SELINE [] NEW [X]				
SUBSYSTEM: MDAC ID: ITEM:	EPG 126 H2 PURGE LINE HE	E HEATERS (2)					
LEAD ANALYST:	M. HIOTT						
ASSESSMENT:							
CRITICAL FLIGH	ITY REDUNDANC F	CY SCREENS	CIL ITEM				
HDW/FU	NC A	ВС					
NASA [/ IOA [3 /3]. [] [] [NA] [] [] NA] [NA]	[] * []				
COMPARE [N/N] [и] [и] [и]	[]]				
RECOMMENDATIONS: (If different from NASA)							
[/] [] [] [] (A	[] DD/DELETE)				
* CIL RETENTION 1	RATIONALE: (If app	licable) ADEQUATE					
REMARKS: A HEATER CANNOT FAIL ON BY ITSELF. FOR A HEATER TO RECEIVE							

A HEATER CANNOT FAIL ON BY ITSELF. FOR A HEATER TO RECEIVE CONTINUOUS POWER, A SWITCH OR THERMOSTAT MUST FAIL CLOSED. THE FAILURE OF A SWITCH OR THERMOSTAT HAS BEEN EVALUATED IN OTHER NASA FMEAS. THE IOA ANALYSIS WORKSHEET 126 HAS BEEN CANCELLED.

REPORT DATE 03/24/87 C-29

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-127		NASA DATA: BASELINE [] NEW [X]				
SUBSYSTEM: MDAC ID: ITEM:	EPG 127 02/H2 FLO	WMETER					
LEAD ANALYST:	M. HIOTT						
ASSESSMENT:							
CRITICAL	ITY R	Y REDUNDANCY SCREENS					
HDW/FUI	NC A	B		с	11DM		
NASA [/ IOA [3 /1R] [] [P] [] [P] [] [] P]	[] *		
COMPARE [N /N] [N	(N] []	ן א	[]		
RECOMMENDATIONS: (If different from NASA)							
[/] [] [] [] (AI	[] DD/DELETE)		
* CIL RETENTION H	RATIONALE:	(If appl)	icable) IN	ADEQUATE ADEQUATE	[]		
REMARKS: IF A FLOWMETER MALFUNCTIONS, THEN LEAKING REACTANT WOULD BE							

UNDETECTABLE WHICH COULD POSSIBLY BE CATASTROPHIC. THE FUSES WHICH PROTECT THE FLOWMETERS ELECTRICALLY HAVE BEEN EVALUATED BY NASA FMEAS BUT THE FLOWMETERS HAVE NOT. THE EFFECT FOR THIS ANALYSIS HAS BEEN COVERED BY NASA FMEA 05-6MA-2012-1, THEREFORE, THE IOA ANALYSIS HAS BEEN CANCELLED.

REPORT DATE 03/24/87
ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/8 FCP-128	L1/28/86 NASA DATA: CP-128 BASELINE NEW								
SUBSYSTEM: MDAC ID: ITEM:	EPG 128 START-U	P HEATER								
LEAD ANALYST:	M. HIOT	T								
ASSESSMENT:										
CRITICALITY REDUNDANCY SCREENS CIL										
HDW/FU	NC	A	В	C	LIEF	1				
NASA [/ IOA [3 /3] [] [NA] [] NA]	[] [NA]] [] *]				
COMPARE [N /N]	ן א]	[N]	[N]	[]				
RECOMMENDATIONS:	(If d	lifferent	from NAS	A)						
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* CIL RETENTION	RATIONAL	E: (If ap	plicable)	_	_				
			:	ADEQUATE INADEQUATE	[]				
REMARKS: THE START/SUSTAINING HEATERS ON FUEL CELL NO. ONE HAVE BEEN DISCONNECTED. THE FUEL CELL START-UP PROCESS WOULD TAKE LONGER WITH A FAILED HEATER. THE FUEL CELL PERFORMANCE COULD POSSIBLY										

BE DEGRADED DUE TO THE LOSS OF THE SUSTAINING HEATERS THAT MAINTAIN THE COOLING TEMPERATURE. THE EFFECT OF THIS ANALYSIS HAS BEEN COVERED BY NASA FMEA 05-6MA-2035-4, THEREFORE, THE IOA ANALYSIS HAS BEEN CANCELLED.

REPORT DATE 03/24/87

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-129		NASA DATA BASELINE NEW	; [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 129 START-UP HEA	ATER		
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH HDW/FUN	ITY REDU F IC A	NDANCY SCREE B	NS C	CIL ITEM
NASA [/] []	г 1	г 1	[]*
IOA [2/1R	j (pj	[P]	[P]	<u>ן</u> ז איז איז איז איז איז איז איז איז איז א
COMPARE [N/N] [N]	[N]	[א]	[]
RECOMMENDATIONS:	(If differ	ent from NAS	A)	
[/] []	[]]	[] (AC	[] DD/DELETE)
* CIL RETENTION F	ATIONALE: (I	f applicable)	
			ADEQUATE INADEQUATE	
REMARKS: A HEATER CANNOT F CONTINUOUS POWER, IOA ANALYSIS WORF	AIL ON BY IT A SWITCH OR SHEET 129 HA	SELF. FOR A THERMOSTAT AS BEEN CANCE	HEATER TO R MUST FAIL CI LLED.	ECEIVE OSED. THE

ASSESSME ASSESSME NASA FME	NT NT A #	DATE: ID: :	11/28 FCP-1 04-1A	/86 30 -010	1-2			N .]	ASA DATA BASELINE NEW	.: [[X]
SUBSYSTE MDAC ID: ITEM:	м:		EPG 130 H2/02	PRE	HEAT	ER					
LEAD ANA	LYS	т:	M. HI	OTT							
ASSESSME	NT:										
	CRI'	TICAL	ITY	R	EDUN	DANCY	SCRI	EENS		CIL	M
	H	DW/FUI	NC	A		В		С		110	
NASA IOA	[2	2 /1R 2 /1R]	[P [P]	[P [P]]	[P [P]	[X [X] *]
COMPARE	[/]	[]	[]	[]	٢]
RECOMMEN	DAT	IONS:	(If	dif	fere	nt fr	om N2	ASA)			
	[/]	[]	[]	[] (A] ELETE)
* CIL RE	TEN	TION I	RATION	ALE:	(If	appl	icab]	Le) AI INAI	DEQUATE DEQUATE	[X []]
REMARKS:											

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ASSESSME ASSESSME NASA FME SUBSYSTE MDAC ID: ITEM: CONDENSE INTERFAC	NT D NT I A #: M: R, F ES.	ATE: D: ILTEI ECLS:	11, FCH 04- EPC 131 H2, RS, FHH	/28/ -13- -1A- - - - - - - - - - - - - - - - - -	'86 1 01 PR RI	5 .01 .EH ./S	-2 EAT UST	ER, AIN ERS	PU	JMP, EATH	, THI ER, 2	N ERI AC	ASA D. BASEL: I MAL CO CUMUL	ATA: INE NEW ONTF ATOI	: [[ROL	X V FI]] ZAL	VE, IBL	E
LEAD ANA	LYST	:	м.	ніо	TI	?													
ASSESSME	NT:																		
	CRIT F HD	ICALI LIGHI W/FUN	ETY P VC			RE A	DUŃ	DAN	CY B	SCI	REEN	s c			CI IT	L Em	[
NASA IOA	[2 [2	/1R /1R]		[[P P]	[[P P]]	[[P P]		[[x x]	*	
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* CIL RET	rent:	ION F	ATI	ONA	LĒ	:	(If	app	91 i	cab	ole) Il	AI NAI	DEQUAI DEQUAI	re re	[x]]		

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-132 04-1A-0101-1	2	NASA DATA BASELINE NEW	.: / [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 132 COOLANT PUM	P		
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH	ITY RED T	UNDANCY SCREE	Ens	CIL ITEM
HDW/FU	NC A	В	С	
NASA [2 /1R IOA [2 /1R] [P]] [P]	[P] [P]	[P] [P]	[X]* [X]
COMPARE [/] []	[]	[]	[]]
RECOMMENDATIONS:	(If diffe	rent from NAS	5A)	
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* CIL RETENTION	RATIONALE: (1	If applicable	e) ADEQUATE INADEOUATE	[X]
REMARKS:				ι J

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-133		NASA DATA: BASELINE NEW	[] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 133 COOLANT PR	ESSURE SWITCH		
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICALI FLIGHT HDW/FUN	ITY RE I NC A	DUNDANCY SCREEN B	rs C	CIL ITEM
NASA [/ IOA [3 /3] [] [NA] [] [] [NA] [[] [NA]	[]* []
COMPARE [N /N] [N] [N] (ן א ן	[]
RECOMMENDATIONS:	(If diff	erent from NASA	A)	
[3 /3] [NA]] [NA] [[NA] (AD	[] D/DELETE)
* CIL RETENTION F	ATIONALE:	(If applicable)		_
		I	ADEQUATE NADEQUATE	[] []
REMARKS: THE COOLANT PRESS PUMP AND SEQUENCE SWITCH ALSO PROVI OPERATING. THE F	URE SWITCH S THE FUEL IDES THE IN AILURE OF S	SENSES THE HEA CELL START. I DICATION THAT I THE COOLANT PRE	AD RISE OF T THE COOLANT THE COOLANT SSURE SWITC	HE COOLANT PRESSURE PUMP IS H WILL CAU:

OPERATING. THE FAILURE OF THE COOLANT PRESSURE SWITCH WILL CAUSE THE LOSS OF SEVERAL IMPORTANT BUT NOT CRITICAL MEASUREMENTS. THE EVENT INDICATOR FOR THE COOLANT PRESSURE SWITCH IS EVALUATED IN NASA FMEA 05-6MA-2155-1, BUT THE PRESSURE SWITCH IS NOT. THE GENERATION OF A NASA FMEA FOR ANALYSIS WORKSHEET 133 IS REQUESTED TO DOCUMENT THE COOLANT PRESSURE SWITCH HARDWARE AND ITS LEVEL OF CRITICALITY.

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-134		NASA DATA: BASELINE NEW	[] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 134 STACK INLET TEM	PERATURE SE	NSOR	
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH	ITY REDUNDA T	NCY SCREENS	_	CIL ITEM
HDW/FU	NC A	В	С	
NASA [/ IOA [3 /3] []] [NA]	[] [[NA] [] NA]	[] * []
COMPARE [N /N] [N]	[N] []	и]	[]
RECOMMENDATIONS:	(If different	from NASA)		
[3 /3] [NA]	[NA] [NA] (AD	[] DD/DELETE)
* CIL RETENTION 2	RATIONALE: (If a	pplicable)	ADEQUATE	[]
REMARKS: THE SENSOR DETEC OUTPUT IS USED B FAILED HIGH PREV	IS THE CELL STAC Y THE START-UP H ENTS START-UP HE	K INLET TEM EATER ELECT ATER OPERAT	PERATURE. RONICS. A ION WHICH	THE SENSOR SENSOR SLOWS DOWN
THE START-UP PRO ONE IS DISCONNEC WORKSHEET 134 IS INLET TEMPERATUR	CESS. THE STARI FED. THE GENERA REQUESTED TO DO E SENSOR.	-UP HEATER TION OF A NA CUMENT THE	FOR FUEL (ASA FMEA F FAILURE OF	OR ANALYSIS THE STACK

THE NASA SUBSYSTEM MANAGER AGREED WITH THE IOA ANALYSIS FOR THIS COMPONENT AND WILL RECOMMEND THIS FAILURE MODE TO ROCKWELL FOR ADDITION TO THE NASA FMEA LIST.

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-135		NASA DATA: BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 135 STACK INLET TE	MPERATURE S	ENSOR	
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH HDW/FU	ITY REDUNI T NC A	DANCY SCREEN	S C	CIL ITEM
			_	
NASA [/ IOA [3 /1R] []] [P]	[] [[P] [] P]	[]* []
COMPARE [N /N] [N]	[N] [N]	[]
RECOMMENDATIONS:	(If differen	nt from NASA)	
[3 /3] [NA]	[NA] [NA] (AI	[] DD/DELETE)
* CIL RETENTION	RATIONALE: (If	applicable) I	ADEQUATE NADEQUATE	
REMARKS:	TS THE CELL STA	CK INLET TE	MPERATURE.	THE SENSOR
OUTPUT IS USED B	Y THE START-UP	HEATER ELEC	TRONICS. A	SENSOR
FAILED LOW WOULD	LOSE ONE PATH	FOR START-U	P HEATER SH	HUTDOWN. THE
REMAINING PATH T	O SHUTDOWN THE	HEATERS IS	THE STACK C	DUTLET
TEMPERATURE SENS	OR AND ELECTRON	VICS AND THE	MANUAL SW	ITCHES. A
FAIL ON WHICH CO	ULD REOUIRE FUE	L CELL SHUT	DOWN. THE	GENERATION
OF A NASA FMEA AN	ND CIL FOR ANAL	YSIS WORKSH	EET 135 IS	
REQUESTED BECAUS	E OF THE POSSII	BLE SHUTDOWN	OF A FUEL	CELL.

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THE NASA SUBSYSTEM MANAGER AGREED WITH THE IOA ANALYSIS AS A 3/3 FOR THIS COMPONENT AND WILL RECOMMEND THIS FAILURE MODE TO ROCKWELL FOR ADDITION TO THE NASA FMEA LIST.

REPORT DATE 03/24/87 C-38

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-136		NASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 136 STACK OUTLET TE	MPERATURE	SENSOR	
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL	ITY REDUNDA	NCY SCREE	NS	CIL
HDW/FU	NC A	В	с	LIEM
NASA [/ IOA [3 /3] []] [NA]	[] [NA]	[] [NA]	[]*
COMPARE [N/N] [N]	[N]	[א]	[]
RECOMMENDATIONS:	(If different	from NAS.	A)	
[3/3] [NA]	[NA]	[NA] (Al	[] DD/DELETE)
* CIL RETENTION 1	RATIONALE: (If a	pplicable) ADEQUATE INADEOUATE	
REMARKS: THE SENSOR DETECT OUTPUT IS USED B SENSOR FAILED HIG FROM OPERATING. FUEL CELL START-T DEGRADE THE FUEL FOR ANALYSIS WORT OF THE SENSOR. THE NASA SUBSYST COMPONENT AND WIT	TS THE CELL STAC Y THE START-UP/S GH PREVENTS THE A FAILED OFF ST UP PROCESS. A F CELL PERFORMANC KSHEET 136 IS RE EM MANAGER AGREH LL RECOMMEND THI	K OUTLET (USTAINING START-UP ART-UP HEA AILED OFF E. THE GH QUESTED TO D WITH TH S FAILURE	TEMPERATURE HEATER ELEG OR SUSTAININ ATER WILL SI SUSTAINING ENERATION OF D DOCUMENT S E IOA ANALYS MODE TO ROO	THE SENSOR CTRONICS. A NG HEATERS LOW THE HEATER COULD F A NASA FMEA THE FAILURE SIS FOR THIS CKWELL FOR
ADDITION TO THE	NASA FMEA LIST.			

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-137	i		NASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 137 STACK OU	TLET TEMP	PERATURE	SENSOR	
LEAD ANALYST:	M. HIOTT				
ASSESSMENT:					
CRITICAL	ITY 1	REDUNDANC	Y SCREE	NS	CIL
HDW/FU	NC 2	A	в	с	LIEM
NASA [/ IOA [3 /1R] [,] [P] [] ₽]	[] [P]	[]*
COMPARE [N /N] [и] [N]	[N]	[]
RECOMMENDATIONS:	(If di	fferent f	rom NAS.	A)	
[3 /3] []	NA] [NA]	[NA] (AD	[] DD/DELETE)
* CIL RETENTION 1	RATIONALE:	: (If app)	licable)	
			1	ADEQUATE INADEOUATE	
REMARKS:				~	
THE SENSOR DETECT	IS THE CEI	LL STACK	OUTLET 7	TEMPERATURE.	THE SENSOR
OUTPUT IS USED BY	Y THE STAP	RT-UP/SUS	TAINING	HEATER ELEC	TRONICS. A
SENSOR FAILED LOU	V PREVENTS	S START-U	P OR SUS	STAINING HEA	TER
SHUTDOWN, WHICH	VOULD REQU	UIRE FUEL	CELL SH	UTDOWN. TH	E GENERATION
OF A NASA FMEA AN BECAUSE OF A DOS	D CLL FOR	ANALYSIS T. OFTI. SH		IEET 137 IS F	REQUESTED

BECAUSE OF A POSSIBLE FUEL CELL SHUTDOWN. THE NASA SUBSYSTEM MANAGER AGREED WITH THE IOA ANALYSIS AS A 3/3 FOR THIS COMPONENT AND WILL RECOMMEND THIS FAILURE MODE TO ROCKWELL FOR ADDITION TO THE NASA FMEA LIST.

ASSESSME ASSESSME NASA FME	ENT ENT EA	DJ II #:	ATE: D:	11 FC 04	./28, P-13 -1A-	/80 88 -01	5 LO 1	L-3					3	NASA BAS	DATA ELINE NEW	.: [[x]	
SUBSYSTE MDAC ID: ITEM:	M:			EP 13 WA	G 8 TER	SE	:P#	RAT	OR	PU	MP								
LEAD ANA	LYS	ST:		м.	HIC	T	2												
ASSESSME	NT:	;																	
	CRI	TI FI	CAL	CTY C			RI	EDUN	DAN	CY	sc	REEN	IS			C) I]	IL CEI	м	
	F	IDW	I/FUI	1C			A			В			(2					
NASA IOA	[[2 2	/1R /1R]]		[[P P]	[[P P]]			?] ?]		[[X X]]	*
COMPARE	[/]		[]		[]	i	[]		נ]	
RECOMMEN	IDA!	FI C	ons:		(If	di	lf:	fere	nt	fr	om	NAS	\)						
	Γ		/]		[]	[]	(•]	(A] DD/	/DI] Elf	ETE)
* CIL RE	TÈN	ITI	ON I	RAT	IONA	LE	:	(If	ap	pl.	ica	ble) I	2 :N2	ADEQ ADEQ	UATE UATE	[r	x]	
REMARKS:														~		-		•	

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-139 04-1A-0103	1-3	N. 1	ASA DATA: BASELINE NEW	[] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 139 Water Sepa	ARATOR PUI	MP/WATER	CONDENSAT	TE TRAP
LEAD ANALYST:	M. HIOTT				
ASSESSMENT:					
CRITICAL FLIGH HDW/FUN	ITY RI I NC A	EDUNDANCY B	SCREENS C		CIL ITEM
NASA [2 /1R IOA [2 /1R] [P]] [P]] [P]] [P] [P]] [P]	[X] * [X]
COMPARE [/] [] [] []	[]
RECOMMENDATIONS:	(If dif:	ferent fro	om NASA)		
[/] [] [] [] (AD	[] D/DELETE)
* CIL RETENTION F	RATIONALE:	(If appli	icable) AI INAI	DEQUATE DEQUATE	[X]
REMARKS:				-	

REPORT DATE 03/24/87 C-42

	ASSESSME ASSESSME NASA FME	ATE: D:	11/28/86 FCP-141 04-1A-0101-2				NASA DATA: BASELINE [] NEW [X]										
	SUBSYSTEM: MDAC ID: ITEM:				EPG 141 THERMAL CONTROL V				VALVE								
	LEAD ANA	:	M. HIOTT														
	ASSESSMENT:																
CRITICALITY]	REDU	NDAN	CY	SCR	EENS	5		C: TT	IL PEN	ſ	
	HDW/FU				NC A				ВС								
	NASA IOA	[2 [2	/lR /lR]]	·	[]	P] P]	[[P P]]	[[P P]	[[X X]	*
	COMPARE	[/]		[]	I	•]	[]	[]	
	RECOMMEN	DATI	ONS:		(If	di	ffer	rent	fr	om N	IASA)					
		C	/]		[]	[]	[] (2] ADD,	/DI] SLE	TÉ)
	* CIL RE	rent:	ION	RAT	IONZ	LE	: (I	f ap	pl:	icab	le) Il	AD NAD	EQUATE EQUATE	[[x]]	
	VELIUVO :																

REPORT DATE 03/24/87 C-43

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ASSESSME ASSESSME NASA FME	/86 12 -010:	1-3				NASA DA BASELI N	ATA: NE IEW	: []	x]]				
SUBSYSTE: MDAC ID: ITEM:	M:		EPG 142 WATER	DISC	CHAR	JE VAI	LVE						*	
LEAD ANA	LYST	:	M. HIC	OTT										
ASSESSME	NT:													
(CRIT: F	ICALI LIGHI	CTY C	RI	EDUNI	DANCY	SCREI	ens			C] II	IL 'EM	ſ	
	HDI	W/FUN	1C	A		В			С					
NASA IOA	[2 [2	/1R /1R]]	[P [P]	[P [P]	[[P] P]		[[X X]]	*
COMPARE	[/]	ן נ]	ַ []	[]		[]	
RECOMMEN	DATI	ONS:	(If	dif	fere	nt fro	om NAS	5A)						
	[/]	[]	[]	[]	(AD	[D/	DE] :LE	TE)
* CIL RET	TENT:	ION F	RATIONA	LE:	(If	appli	cable) IN	ADEQUAT ADEQUAT	e E E	ו ב נ	X]	
REMARKS:														

REPORT DATE 03/24/87

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-143 04-1A-010	1-3		NASA DATA BASELINE NEW	A: [] [X]		
SUBSYSTEM: MDAC ID: ITEM:	EPG 143 H20 DISCH	ARGE L	INE				
LEAD ANALYST:	M. HIOTT						
ASSESSMENT:							
CRITICAL FLIGH	ITY R T	EDUNDA	NCY SCRE	ENS	CIL ITEM		
HDW/FU	NC A		В	с			
NASA [2 /1R IOA [2 /1R] [P]] [P]]	[P] [P]	[P] [P]	[X]* [X]		
COMPARE [/] []	[]	[]	[]		
RECOMMENDATIONS:	(If dif	ferent	from NA	SA)			
[/] []	[]]	[] (A	[] DD/DELETE)		
* CIL RETENTION	RATIONALE:	(If a <u>r</u>	pplicabl	e) ADEQUATE INADEOUATE	[X] []		
REMARKS:							

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-144		NASA DATA BASELINE NEW	: [] []							
SUBSYSTEM: MDAC ID: ITEM:	EPG 144 PH WATER SENSC	R									
LEAD ANALYST:	M. HIOTT										
ASSESSMENT:	SSESSMENT:										
CRITICALITY REDUNDANCY SCREENS CIL FLIGHT TTEM											
HDW/FUN	A DI	В	С								
NASA [/ IOA [3 /3] []] [NA]	[] [NA]	[] [NA]	[]*							
COMPARE [N/N] [N]	[N]	[N]	[]							
RECOMMENDATIONS:	(If differen	t from NA	SA)								
[3/3] [NA]	[NA]	[NA] (A)	[] DD/DELETE)							
* CIL RETENTION F	ATIONALE: (If a	applicabl	e) ADEQUATE INADEQUATE								
REMARKS:	FATTS THEN THE	F DU CAN I									
LITMUS PAPER. TH	LITMUS PAPER. THE GENERATION OF A NASA FMEA AND CIL FOR ANALYSIS										
WORKSHEET 144 IS WATER SENSOR.	REQUESTED TO D	OCUMENT T	HE FAILURE O	F THE pH							
THE NASA SUBSYSTE	M MANAGER AGRE	ED WITH T	HE IOA ANALY	SIS FOR THIS							

THE NASA SUBSYSTEM MANAGER AGREED WITH THE IOA ANALYSIS FOR THIS COMPONENT AND WILL RECOMMEND THIS FAILURE MODE TO ROCKWELL FOR ADDITION TO THE NASA FMEA LIST.

REPORT DATE 03/24/87

ASSESSME ASSESSME NASA FME	11/2 FCP- 04-1	8/86 145 A-015	NASA DATA: BASELINE [] NEW [X]								
SUBSYSTE MDAC ID: ITEM:	EPG 145 PRODUCT WATER LINE TEMPERATURE						ATURE SE	NSOR			
LEAD ANA	м. н	M. HIOTT									
ASSESSME	ASSESSMENT:										
	ITY T	ITY REDUNI			C SCR	EENS	5	CIL ITEM			
	HD	W/FU	NC A			I	3		С		
NASA IOA	[3 [3	/3 /3]]	[N [N	A] A]	1] 1]	NA] NA]	[[NA] NA]	- [[] *]
COMPARE	[1]	[]	[]	נ]	[]
RECOMMEN	IDATI	ONS:	(I	f dif	fere	ent fi	com N	ASA)			
	[/	1	[]	[]	Γ]	[(ADD/I] DELETE)
* CIL RE	ION	RATIO	NALE:	(If	appl	icab	le) IN	ADEQUAT	E (E r]	
REMARKS:										- L	J

ASSESSMEN ASSESSMEN NASA FMEA	T DATE T ID: . #:	: 11/28 FCP-1	3/86 46		NASA DAT BASELIN NE	A: E [W [X]
SUBSYSTEM MDAC ID: ITEM:	:	EPG 146 PROD	JCT WATER	LINE HEA	TER (A&B)		
LEAD ANAL	YST:	M. HI	OTT				
ASSESSMEN	т:						
C	RITICA FLIG	LITY HT	REDUNI	DANCY SCR	EENS	CIL ITEM	ſ
	HDW/F	UNC	Α	B	С		
NASA IOA	[/ [3 /3]]	[] [NA]	[] [NA]	[] [NA]	[[] *]
COMPARE	[N /N]	[N]	[N]	[N]	[]
RECOMMEND	ATIONS	: (If	differe	nt from N	ASA)		
	[/]	[]	[]	[]	[ADD/DE] LETE)
* CIL RET	ENTION	RATION	ALE: (If	applicab	le) ADEQUATE INADEQUATE	[[]
REMARKS: A HEATER (CONTINUOUS	CANNOT S POWEI	FAIL O R. A SW	N BY ITSE ITCH OR T	LF. FOR	A HEATER TO	RECEI CLOSEI	VE). THE

CONTINUOUS POWER, A SWITCH OR THERMOSTAT MUST FAIL CLOSED. THE FAILURE OF A SWITCH OR THERMOSTAT HAS BEEN EVALUATED IN OTHER NASA FMEAS. THE IOA ANALYSIS WORKSHEET 146 HAS BEEN CANCELLED.

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-147 04-1A-0144-1	NASA BASI	DATA: CLINE [] NEW [X]							
SUBSYSTEM: MDAC ID: ITEM:	EPG 147 PRODUCT WATEF	EPG 147 PRODUCT WATER LINE HEATER (A&B)								
LEAD ANALYST:	M. HIOTT									
ASSESSMENT:										
CRITICAL FLIGH	ITY REDUN F	DANCY SCREENS	CIL ITEM							
HDW/FU	NC A	B C								
NASA [3 /3 IOA [3 /3] [NA]] [NA]	[NA] [NA] [NA] [NA]	[] * []							
COMPARE [/] []	[][]	[]							
RECOMMENDATIONS:	(If differe	ent from NASA)								
[/] []	[]][]	[] (ADD/DELETE)							
* CIL RETENTION 1	RATIONALE: (If	applicable) ADEQU INADEQU	ATE [] ATE []							
REMARKS:										

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ASSESSMENT D ASSESSMENT I NASA FMEA #:	ATE: 11/28 D: FCP-1 04-1A	48 48 -0136-1		NASA I BASEI	DATA: LINE [] NEW [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 148 PRODU	CT WATER	LINE		
LEAD ANALYST	: M. HI	OTT			
ASSESSMENT:					
CRIT	ICALITY LIGHT	REDUN	CIL ITEM		
HDV	N/FUNC	A	В	C	
NASA [2 IOA [2	/1R] /1R]	[P] [P]	[P] [P]	[P] [P]	[] * []
COMPARE [/]	[]	[]	[]	[]
RECOMMENDATIO	ONS: (If	differe	nt from N	IASA)	
[/]	[]	[]	[]	[] (ADD/DELETE)
* CIL RETENTI REMARKS:	ON RATION	ALE: (If	applicab	ole) ADEQUA INADEQUA	TE [X] TE []

REPORT DATE 03/25/87 C-50

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-148A 04-1A-0136-2		NASA DATA: BASELINE [] NEW [X]						
SUBSYSTEM: MDAC ID: ITEM:	EPG 148 PRODUCT WATER	LINE							
LEAD ANALYST:	M. HIOTT	M. HIOTT							
ASSESSMENT:									
CRITICAL FLIGH HDW/FU	ITY REDUNI F NC A	DANCY SCREENS	2	CIL ITEM					
NASA [3 /1R IOA [3 /1R] [P]] [P]	[P] [] [P] []	P] P]	[X] * [X]					
COMPARE [/] []	[][]	[]					
RECOMMENDATIONS:	(If differe	nt from NASA)							
[/] []	ניז נ] (AI	[] D/DELETE)					
* CIL RETENTION	RATIONALE: (If	applicable) 7 IN7	ADEQUATE ADEQUATE	[X] []					

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ASSESSME ASSESSME NASA FME	ENT I ENT I EA #:	DATE: D:	11/28 FCP-1 04-1A	3/86 49 -012:	/86 NASA 49 BAS -0122-3					DATA: ELINE [] NEW [X]		
SUBSYSTE MDAC ID: ITEM:	M:		EPG 149 WATEF	PLY (CHECK	VALVE	;					
LEAD ANA	LYST	:	M. HI	OTT								
ASSESSME	NT:											
	CRIT F	ICAL	ITY F	RI	EDUN	DANCY	SCREE	ns C		C: 17	IL EM	
	пр	w/rui	NC	A		D		C				
NASA IOA	[3 [3	/1R /2R]	[P [P]]	[P [P]]	[P [F]]	[[x]	*
COMPARE	[/ N]	[]	[]	[N	[]	[N]	
RECOMMEN	IDATI	ONS:	(If	dif:	fere	nt fro	om NAS	A)				
	C	/]	[]	[J _	[]	[(ADD/] DEL	ete)
* CIL RE	TENT	ION H	RATION	ALE:	(If	appli	cable) Al INA	DEQUAI DEQUAI	TE [TE []]	
THE DISC DECISION	USSI TO	ON WI CHANC	(TH TH SE THE	E NAS IOA	SA SU ANAI	JBSYSI LYSIS	EM MA	NAG TS 2	ER RES IO 3/1	SULTEI LR ANI	D IN D AGI	A REE

WITH THE NASA FMEA. AN EXTERNAL LEAK WOULD FREEZE CAUSING THE CHECK VALVE TO FAIL CLOSE.

REPORT DATE 03/24/87 C-52

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-150 04-1A-0123	2-2		NASA DATA: BASELINE [] NEW [X]					
SUBSYSTEM: MDAC ID: ITEM:	EPG 150 WATER SUPI	PLY CHECK	VALVE						
LEAD ANALYST:	M. HIOTT								
ASSESSMENT:									
CRITICAL FLIGH HDW/FU	ITY RI T NC A	REDUNDANCY SCREENS			CIL ITEM				
IDW/FO	NC A	Б							
NASA [3 /1R IOA [3 /1R] [P]] [P]] [P]] [P] [P] P]	[] * []				
COMPARE [/] [J [י נ]	[]				
RECOMMENDATIONS:	(If dif:	ferent fro	om NASA)						
[/] [] [] [] (A)	[] DD/DELETE)				
* CIL RETENTION	RATIONALE:	(If appli	cable) IN	ADEQUATE ADEQUATE	[]				
REMARKS:									

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ASSESSMENT DATE: 11/ ASSESSMENT ID: FCP NASA FMEA #: 04-				11/28, FCP-15 04-1A-	/86 51 -012:	2-1				NASA DATA BASELINE NEW	: [[X]]
SUBSY MDAC ITEM:	STEM ID:	1:		EPG 151 WATER	SUP	bra c	HECK	VALVI	Ξ			
LEAD .	ANAI	lys:	C:	M. HIC	TTC							
ASSES	SSESSMENT:											
	c	RIT	FICALI FLIGH	ľty ř	RI	EDUNI	DANCY	SCREI	ens		CIL ITE	м
		HI	OW/FUI	NC	A		В		:	С		
NA: I	SA OA	[3	3 /2R 3 /2R]]	[P [P]	[F [F]]	[P] P]	[X [X] *]
COMPA	RE	[/]	[]	Γ]	[]	Γ]
RECOM	MENI	DAT	IONS:	(If	dif	ferer	nt fro	om NAS	5A)			
		[/]	[]	Ţ]	[] (AI	[מ/סכ] ELETE)
* CIL	RET	ENT	TION F	RATIONA	LE:	(If	appli	cable	≥) IN2	ADEQUATE ADEQUATE	[X []
REMARI	KS:											

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-152 04-1A-0119-3		NASA DATA: BASELINE NEW	[] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 152 WATER RELIEF VA	LVE		
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICALI FLIGHT	ITY REDUNDA	ANCY SCREENS		CIL ITEM
HDW/FUN	IC A	В	C	
NASA [2/2 IOA [3/2R] [NA]] [P]	[NA] [] [P] []	NA] F]	[X] * [X]
COMPARE [N/N] [N]	[N] [I	4]	[]
RECOMMENDATIONS:	(If differen	t from NASA)	-	
[/] []	[][] (AI	[] DD/DELETE)
* CIL RETENTION F	RATIONALE: (If a	applicable) I INZ	ADEQUATE ADEQUATE	[X] []
THE DISCUSSION WI	TH THE NASA SUI	SYSTEM MANA	GER RESULI	TED IN A

DECISION TO CHANGE THE IOA ANALYSIS RESULTS TO 2/2 AND AGREE WITH THE NASA FMEA. THIS DECISION WAS MADE BECAUSE OF THE UNKNOWN AFFECTS OF WATER IN THE PAYLOAD BAY.

REPORT DATE 03/24/87 C-55

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-153 04-1A-0119	-2	NASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 153 WATER RELIE	IF VALVE		
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH	TY REI	DUNDANCY SCREEN	S	CIL ITEM
HDW/FUI	IC A	В	C	
NASA [2/2 IOA [3/2R] [NA]] [P] [NA] [] [P] [NA] P]	[X]* []
COMPARE [N/N] [N	ן [א] [ן א]	[и]
RECOMMENDATIONS:	(If diffe	erent from NASA	.)	
[/] []] (AI	[] DD/DELETE)
* CIL RETENTION P	ATIONALE: ((If applicable) I	ADEQUATE NADEQUATE	[X] []
THE IOA ANALYSIS	HAS BEEN CH	HANGED TO AGREE	WITH THE N	ASA FMEA

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DUE

TO A DISCUSSION WITH THE NASA SUBSYSTEM MANAGER. THE WATER RELIEF VALVE DOES NOT HAVE A REDUNDANT COMPONENT. THE FAILURE OF WATER VENTING MAY INTERFERE WITH THE MISSION OR PAYLOAD OBJECTIVES.

REPORT DATE 03/24/87

ASSESSMENT ASSESSMENT NASA FMEA #	DATE: 11/28 ID: FCP-1 : 04-1A	/86 54 -0119-1		NASA DATA BASELINE NEW	A: 2 [] 7 [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 154 WATER	RELIEF V	ALVE		
LEAD ANALYS	г: м. ні	OTT			
ASSESSMENT:					
CRI I HI	FICALITY FLIGHT DW/FUNC	REDUNI A	DANCY SCRE	ENS	CIL ITEM
NASA [: IOA [:	3 /1R] 3 /1R]	[P] [P]	[NA] [NA]	[P] [P]	[]*
COMPARE [/]	[]]	[]	[]	[]
RECOMMENDAT	IONS: (If	differe	nt from NA	SA)	
ſ	/]	[]	[]	[] (A	[] .DD/DELETE)
* CIL RETENT	TION RATION	ALE: (If	applicabl	e) ADEQUATE INADEQUATE	[] []

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ASSESSME ASSESSME NASA FME	NT DA NT II A #:	ATE: D:	11/28 FCP-1 04-1A	/86 55 -013	8-1				NASA BASE	DATA: LINE NEW	[[X]]
SUBSYSTE MDAC ID: ITEM:	М:		EPG 155 WATER	REL	IEF V	VAL	/E H	EATEP	R (A&B)			
LEAD ANA	LYST:		M. HI	OTT								
ASSESSME	NT:											
	CRITI FL	CALI	TY	R	EDUNI	DANC	Y SC	CREEN	S)	CIL ITEM	
	HDW	/FUN	ĨĊ	A			В		С			
NASA IOA	[3 [3	/1R /1R]	[P [P]]	[[NA] P]	[[P] P]		ני ני] *
COMPARE	[/]	Γ]	[ן א	[]		נ ז]
RECOMMEN	DATIC	NS:	(If	dif	ferer	nt f	rom	NASA)			
	[/]	[]	[]	[]	(ADI	[D/DEI	 LETE)
* CIL RE	FENTI	on r	ATION	ALE:	(If	app	lica	able) I	ADEQUA NADEQUA	ATE ATE		
THE WATE	R REL R REL	IEF IEF	SYSTEI VALVE	M IS HEA	A SI TERS	'AND ARE	BY R STA	EDUN	DANT SY REDUN	STEM, DANT.	THE THE	EREFORE

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REDUNDANCY SCREEN B SHOULD BE NOT APPLICABLE (NA) BECAUSE OF PARAGRAPH 2.3.4 b.1.(b) IN NSTS 22206 FOR THIS HARDWARE. THE IOA ANALYSIS DID NOT CONSIDER THE WATER RELIEF SYSTEM AS REDUNDANT, BUT NOW AGREES WITH THE NASA FMEA.

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-156			NASA DAT BASELIN NE	A: E [W [X]]
SUBSYSTEM: MDAC ID: ITEM:	EPG 156 WATER RELI	IEF VALV	E HEATER	R A&B		
LEAD ANALYST:	M. HIOTT					
ASSESSMENT:				•		
CRITICAL	ITY RI T	EDUNDANC	Y SCREEN	IS	CIL ITEN	4
HDW/FUN	IC A		В	С		
NASA [/ IOA [3 /3] [] [N2] [A] [:] [NA] [] NA]	[[] *]
COMPARE [N/N	א] [א	ן בי ני	м] [[N]	[]
RECOMMENDATIONS:	(If dif:	ferent f	rom NASA	A)		
[/] [] [] [] (4	[ADD/DI] ELETE)
* CIL RETENTION F	ATIONALE:	(If app)	licable) I	ADEQUATE NADEQUATE	[[]
REMARKS: A HEATER CANNOT F	FAIL ON BY	ITSELF.	FOR A	HEATER TO	RECEI	VE

A HEATER CANNOT FAIL ON BY ITSELF. FOR A HEATER TO RECEIVE CONTINUOUS POWER, A SWITCH OR THERMOSTAT MUST FAIL CLOSED. THE FAILURE OF A SWITCH OR THERMOSTAT HAS BEEN EVALUATED IN OTHER NASA FMEAS. THE IOA ANALYSIS WORKSHEET 156 HAS BEEN CANCELLED.

REPORT DATE 03/24/87 C-59

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ASSESSMEI ASSESSMEI NASA FMEI	NT D NT I A #:	DATE:	11/ FCP 04-	28/86 -157 1A-01	5 .25-1				NASA BASE	DATA LINE NEW	:]]	x]
SUBSYSTEN MDAC ID: ITEM:	M:		EPG 157 WAT	ER RE	LIEF	VALV	e ten	IPER.	ATURE	SENS	OR	
LEAD ANAI	LYST	:	м.	HIOTT	1							
ASSESSMEN	1T:											
C	CRIT	ICAL LIGH	ITY T		REDUN	IDANC	Y SCI	REENS	5		CI ITI	L EM
	HD	W/FU	NC		A		в		C			
NASA IOA	[3 [3	/3 /3]]	[[NA] NA]	[ני	NA] NA]	[[NA] NA]		[[] *] •
COMPARE	[1]	[<u>ן</u>	C]	[]		[]
RECOMMEN	DATI	ONS:	(If di	ffere	ent f	rom 1	IASA)	I			
	[/]	[`]	[]	נ]	(AI	[)D/1] DELETE)
* CIL RET	'ENT	ION	RATI	ONALE	: (If	app	Licab	ole) TN		ATE ATE	a bata Ç	
REMARKS:	=	••;						` ه طب ر			L	1

REPORT DATE 03/24/87

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ASSESSME ASSESSME NASA FME	NT D NT I A #:	ATE: D:	11/2 FCP- 04-1	8/86 157A A-012	5-2				NASA I BASEI	DATA LINE NEW	: [[X]	
SUBSYSTE MDAC ID: ITEM:	М:		EPG 157 WATE	R REL	IEF	VALV	E TEM	PERA	TURE S	SENS	OR		
LEAD ANA	LYST	:	м. н	IOTT									
ASSESSME	NT:												
	CRIT F HD	ICAL LIGH W/FU	ITY T NC	R	EDUN	DANC	Y SCR	EENS	c		CII ITE	M	
NASA IOA	[3 [3	/3 /3]]	[N. [N.	A] A]	[] []	NA] NA]	[[NA] NA]		[[]	*
COMPARE	[/]	ſ]	[]	[]		Γ]	
RECOMMEN	IDATI	ONS:	(I	f dif	fere	ent f	rom N	ASA)					
	[/]	C]	[]	[]	(A)])ELE'	TE)
* CIL RE	TENT	ION	RATIO	NALE:	(If	app	licab	le) IN	ADEQU/ ADEQU/	ATE ATE	[[]]	

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-158 04-1A-0133-1	NASA BASE	DATA: LINE [] NEW [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 158 WATER RELIEF	LINE TEMPERATURE S	ENSOR
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICAL	ITY REDU	NDANCY SCREENS	CIL
HDW/FU	NC A	B C	11 Eri
NASA [3 /3 IOA [3 /3] [NA]] [NA]	[NA] [NA] [NA] [NA]	[]*
COMPARE [/] []		[]
RECOMMENDATIONS:	(If differ	ent from NASA)	
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* CIL RETENTION	RATIONALE: (I	f applicable) ADEQU INADEQU	ATE [] ATE []

REPORT DATE 03/24/87

ASSESSMENT DATE: 11/28/86 ASSESSMENT ID: FCP-158A NASA FMEA #: 04-1A-0133-2							NASA DA BASELI N	TA: NE EW	[[X]]			
	SUBSYSTE MDAC ID: ITEM:	M:		EPG 158 WATER	REL	,IEF	LINE	TEMP	ERAI	TURE SEN	SOR		
	LEAD ANA	LYST	:	M. HI	OTT								
	ASSESSME	NT:	*										
	(CRIT F	ICAL LIGH	ITY F	R	EDUN	DANCY	SCR	EENS	5	(]	CIL TEM	
		HD	W/FU	NC	A	•	E	3		С			
	NASA IOA	[3 [3	/3 /3]]	[N [N	A] A]	[] []	IA] IA]	[[NA] NA]		[] *]
	COMPARE	[/]	[]	۵]	נ]		[]
	RECOMMEN	DATI	ONS:	(If	dif	fere	ent fi	rom N	ASA)				
		[/]	[]	[]	[]	(ADI	[D/DE] LETE)
	* CIL RE	FENT	ION	RATION	ALE:	(If	appl	icab	le) IN	ADEQUAT IADEOUAT	E E	[]
	REMARKS:				•							•	-

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ASSESSMENT DA ASSESSMENT IL NASA FMEA #:	ATE: 11/28/ D: FCP-15 04-1A-	'86 9 0109-1		NASA DATA BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 159 WATER	RELIEF (VENT) LINE	5	
LEAD ANALYST:	M. HIO	TT			
ASSESSMENT:					
CRITI FL HDW	CALITY JGHT /FUNC	REDUND. A	ANCY SCREE B	ENS C	CIL ITEM
NASA [3	/1R]	[P]	[NA]	[P]	[]*
IOA [2	/1R]	[P]	[NA]	[P]	[]
COMPARE [N	/]	[]	[]	[]	[]
RECOMMENDATIC	NS: (If	differen	t from NAS	SA)	
[/]	[]]	[]	[] (AI	[] DD/DELETE)
* CIL RETENTI	ON RATIONA	LE: (If a	applicable	≥) ADEQUATE INADEQUATE	[X] []
REMARKS: ADDITION OF T CRITICALITY 3	HE ALTERNA . IOA AGR	TE WATER EES WITH	LINE HAS THE NASA	MADE THIS HA	ARDWARE N.

REPORT DATE 03/24/87 C-64

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-160 04-1A-0141-1	NASA DAT BASELIN NEV	A: E [] W [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 160 WATER VENT LINE	HEATER A&B AND BAR	REL HEATER A&B
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICAL FLIGH HDW/FUI	ITY REDUNDAN F NC A	ICY SCREENS B C	CIL ITEM
NASA [3 /1R IOA [3 /1R] [P] [] [P] [P] [P] P] [P]	[] * []
COMPARE [/] []	[]][]	Ĺ J
RECOMMENDATIONS:	(If different	from NASA)	
[/] [] [] [] (2	[] ADD/DELETE)
* CIL RETENTION N	RATIONALE: (If ap	plicable) ADEQUATE INADEQUATE	

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-161	NASA DATA: BASELINE [] NEW [X]					
SUBSYSTEM: MDAC ID: ITEM:	EPG 161 WATER VENT LIM	NE HEATER A&B AND	BARREL HEATER A&B				
LEAD ANALYST:	M. HIOTT						
ASSESSMENT:							
CRITICAL FLIGH HDW/FU	ITY REDUND F NC A	ANCY SCREENS B C	CIL ITEM				
NASA [/	1 []		Г] *				
IOA [3/3	j įnaj	[NA] [NA]	č j				
COMPARE [N /N] [И]	[N] [N]	[]				
RECOMMENDATIONS:	(If differen	t from NASA)					
[/] []	[]][]]	[] (ADD/DELETE)				
* CIL RETENTION RATIONALE: (If applicable) ADEQUATE [] INADEQUATE []							
REMARKS: A HEATER CANNOT FAIL ON BY ITSELF. FOR A HEATER TO RECEIVE CONTINUOUS POWER, A SWITCH OR THERMOSTAT MUST FAIL CLOSED. THE FAILURE OF A SWITCH OR THERMOSTAT HAS BEEN EVALUATED IN OTHER							

NASA FMEAS. THE IOA ANALYSIS WORKSHEET 161 HAS BEEN CANCELLED.

REPORT DATE 03/24/87
ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-162		NASA DATA BASELINE NEW	: [] [X]	
SUBSYSTEM: MDAC ID: ITEM:	EPG 162 WATER NOZZLE :	HEATER (A&B)			
LEAD ANALYST:	M. HIOTT				
ASSESSMENT:					
CRITICALITY REDUNDANCY SCREENS				CIL ITEM	
HDW/FU	NC A	В	С		
NASA [/ IOA [3 /3] []] [NA]	[] [[NA] [] NA]	[] []	*
COMPARE [N/N] [И]	ן א]	ן א	[]	
RECOMMENDATIONS:	(If differen	nt from NASA)			
[/] []	[]] [] (AI	[] DD/DEL	ETE)
* CIL RETENTION	RATIONALE: (If	applicable)			
		IN	ADEQUATE ADEQUATE		
REMARKS: A HEATER CANNOT CONTINUOUS POWER FAILURE OF A SWI	FAIL ON BY ITSE , A SWITCH OR T TCH OR THERMOST	LF. FOR A H HERMOSTAT MU AT HAS BEEN	EATER TO F IST FAIL CI EVALUATED	ECEIV LOSED. IN OT	E THE HER

NASA FMEAS. THE IOA ANALYSIS WORKSHEET 162 HAS BEEN CANCELLED.

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REPORT DATE 03/24/87 C-67

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ASSESSME ASSESSME NASA FME	NT I NT I A #:	DATE:	11/28 FCP-10 04-1A	/86 53 -0100	5-2			1	NASA BASE	DATA LINE NEW	: · · · · · · · · · · · · · · · · · · ·	(]	·· -· <u>-</u>
SUBSYSTE MDAC ID: ITEM:	M:		EPG 163 WATER	NOZ	ZLE	HEATE	R (2	A&B)					
LEAD ANA	LYST	:	M. HIG	OTT									
ASSESSME	NT:											Ŧ	10.42
(CRIT F	ICAL	ITY F	RI	EDUN	DANCY	SCI	REENS			CII ITE	- M	
	HD	W/FUI	NC	A		В		Ċ	2				
NASA IOA	[3 [2	/1R /1R]	[P [P]	[NA [P]	[]	P] P]		[[] *] -	₩2
COMPARE	[]	1 /]	[]	[N]	[]		[]	
RECOMMEN	DATI	ONS:	(If	dif	fere	nt fro	om 1	NASA)					
	۵	/]	[]	[]	[]	(AI	[DD/I] DELET	E)
* CIL RE	TENT	ION I	RATION!	ALE:	(If	appli	cab	ole) INA	DEQUADEQUA	ATE ATE (STEM	()]]	(]]	FORF
THE WATE	R NO	ZZLE	HEATER	RS AF	RE S	TANDBY	RE	DUND	NT.	THE	RED	UNDAI	NCY

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SCREEN B SHOULD BE NOT APPLICABLE (NA) BECAUSE OF PARAGRAPH 2.3.4 b.2 (b) IN NSTS 22206 FOR THIS HARDWARE. ADDITION OF THE ALTERNATE WATER LINE HAS MADE THIS HARDWARE CRITICALITY 3. IOA AGREES WITH THE NASA REEVALUATION.

REPORT DATE 03/24/87

C-68

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-164 04-1A-0150-1	1	NASA DATA: BASELINE NEW	: [] [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 164 Water Relie:	F NOZZLE TEMPE	RATURE SENS	SOR
LEAD ANALYST:	M. HIOTT			
ASSESSMENT:				
CRITICAL FLIGH	ITY REDU F	JNDANCY SCREEN	'S	CIL ITEM
		B		
NASA [2/1R IOA [2/1R] [P]] [P]	[P] [[P] [P] P]	[X]* [X]
COMPARE [/] []	[]][.	[]
RECOMMENDATIONS:	(If diffe	rent from NASA	()	
[/] []	[]][] (AI	[] DD/DELETE)
* CIL RETENTION D	RATIONALE: ()	f applicable) I	ADEQUATE NADEQUATE	[X] []
REMARNO :				

ASSESSME ASSESSME NASA FME	NT D NT I A #:	ATE: D:	11/28, FCP-10 04-1A-	/86 54A -0150	0-2			NASA I BASEI	DATA: LINE NEW	[[X]]
SUBSYSTE MDAC ID: ITEM:	M:		EPG 164 WATER	REL	IEF	NOZZLI	E TEMP	ERATURE	SENS	SOR	
LEAD ANA	LYST	:	M. HIC	TT							
ASSESSME	NT:										
(CRIT: FI	ICALI LIGHI	TY ?	RI	EDUN	DANCY	SCREE	NS		CIL ITEI	4
	HD	W/FUN	IC	A		В		С			
NASA IOA	[3 [3	/1R /1R]	[P [P]	[P [P]	[P] [P]		[X [X] *]
COMPARE	Č	/	1	[]	[]	[]		[]
RECOMMEN	DATI	ONS:	(If	dif	fere	ent fro	om NAS	A)			
	[/]	[]	[]	[]	(AD	[נס/סי] ELETE)
* CIL RET	FENT:	ION F	ATIONA	LE:	(If	appli	cable) ADEQUA	TE	ĮΧ	ļ
REMARKS:								TNADEQUA	. 1 . Ei	L	1

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	11/28/86 FCP-165 04-1A-0106-1	NA Bi	SA DATA: ASELINE [] NEW [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 165 WATER NOZZLE		
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICAL FLIGH	ITY REDUNI T	DANCY SCREENS	CIL ITEM
HDW/FU.	NC A	вс	
NASA [3/1R IOA [2/1R] [P]] [P]	[NA] [P [NA] [P	[] * []
COMPARE [N/) []	[]][]]	[]
RECOMMENDATIONS:	(If differen	nt from NASA)	
[/] []	[] []	[] (ADD/DELETE)
* CIL RETENTION	RATIONALE: (If	applicable) ADI INADI	QUATE [X] SOUATE []
REMARKS: ADDITION OF THE A CRITICALITY 3.	ALTERNATE WATER IOA AGREES WITH	R LINE HAS MADE I THE NASA REEV.	THIS HARDWARE ALUATION.

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ASSESSME ASSESSME NASA FME	NT I NT I A #:	DATE:	12/23 FCP-1 04-1A	/86 66X -012	8-1				NASA D BASEL	ATA: INE NEW	: [[X] (] .
SUBSYSTE MDAC ID: ITEM:	м:		EPG 166 COOLAI	NT R	ETUR	N TEN	IPERA	TURI	E SENSO	R		
LEAD ANA	LYST	:	M. HI	TTC								
ASSESSME	NT:											
	CRIT F HD	ICAL LIGH W/FUI	ITY F NC	R A	EDUN	DANCY	K SCR	EENS	c		CII ITE	M
NASA IOA	[3 [3	/3 /3]]	[N [N	A] A]	[] []	IA] IA]	[[NA] NA]		[[]*
COMPARE	[/]	[]	[]	[]		[]
RECOMMEN	DATI	ONS:	(If	dif	fere	nt fi	com N	ASA)				
	[/]	[]	[]	<u></u> []	(AD	[D/D] ELETE)
* CIL RE	rent:	ION P	RATIONA	LE:	(If	appl	icab	le) IN	ADEQUAI ADEQUAI	E E	[]
REMARKS:											-	.

REPORT DATE 03/24/87

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	12/23/86 FCP-167X 04-1A-0128-2	NASA I Basei	DATA: JINE [] NEW [X]
SUBSYSTEM: MDAC ID: ITEM:	EPG 167 COOLANT RETURN	TEMPERATURE SENSC	R
LEAD ANALYST:	M. HIOTT		
ASSESSMENT:			
CRITICAL FLIGH	ITY REDUND T	ANCY SCREENS	CIL ITEM
HDW/FU	NC A	B C	
NASA [3 /3 IOA [3 /3] [NA]] [NA]	[NA] [NA] [NA] [NA]	[] * []
COMPARE [/] []	[]][]	[]
RECOMMENDATIONS:	(If differen	t from NASA)	
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* CIL RETENTION 1	RATIONALE: (If a	applicable) ADEQUA INADEQUA	TE [] TE []
REMARKS:		-	• •

REPORT DATE 03/24/87 C-73

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	12/23/80 FCP-1682 04-1A-02	6 X 144-3		NASA DATA BASELINE NEW	: [] [X]	· · · ·
SUBSYSTEM: MDAC ID: ITEM:	EPG 168 FCP PROI	DUCT WATE	R LINE HEA	TER		
LEAD ANALYST:	M. HIOTT	. HIOTT				
ASSESSMENT:						
CRITICAL	ITY	REDUNDAN	CY SCREENS	;	CIL	
HDW/FUI	4C	A	В	с	T T 1914	
NASA [3 /3 IOĀ [3 /3] [NA] [NA] [NA] [NA] [NA] NA]		*
COMPARE [/] [] [] []	[]	
RECOMMENDATIONS:	(If d:	ifferent :	from NASA)			
[/	J [] [] []	[] DD/DEI	ETE)
* CIL RETENTION P	RATIONALE	E: (If app	licable) IN	ADEQUATE ADEQUATE	[] []	
REMARKS: THIS FAILURE CAN THERMOSTAT FAILUN SWITCH AND THERMO AND 04-1A-0151-1 THE SCOPE OF THIS RECOMMENDED FOR 1	OCCUR ON RE CAUSEI OSTAT HAV RESPECTI S TASK. DELETION.	ILY BY CRE D BY VIBRA VE BEEN EV IVELY. CF THEREFORE	W ACTION ATION OR M VALUATED I REW ERROR , FMEA 04	OR BY SWIT ECHANICAL N FMEAS 05 IS NOT WIT -1A-0144-3	CH OR SHOCK -6MA- HIN IS B	. THE 2037-1 EING

FMEA 04-1A-0144-3 HAS ALREADY BEEN DELETED BY THE NASA SUBSYSTEM MANAGER.

REPORT DATE 03/24/87

C-74

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ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	12/23/86 FCP-169X 04-1A-0144-4		NASA DATA BASELINE NEW	: [X]		
SUBSYSTEM: MDAC ID: ITEM:	EPG 169 FCP PRODUCT WA	ATER LINE HE	ATER			
LEAD ANALYST:	M. HIOTT					
ASSESSMENT:						
CRITICAL	ITY REDUNI	DANCY SCREEN	S	CIL		
HDW/FU	NC A	В	С	11211		
NASA [3 /3 IOA [3 /3] [NA]] [NA]	[NA] [[NA] [NA] NA]	[] * []		
COMPARE [/] []	[]][1	[]		
RECOMMENDATIONS:	(If differen	nt from NASA)			
[/] []	[]][]] (A	[] DD/DELETE)		
* CIL RETENTION 2	RATIONALE: (If	applicable)	ADEQUATE	[]		
REMARKS: THIS FAILURE CAN THERMOSTAT FAILU SWITCH AND THERM AN 04-1A-0151-1	OCCUR ONLY BY RE CAUSED BY VI OSTAT HAVE BEEN RESPECTIVELY.	CREW ACTION IBRATION OR N EVALUATED CREW ERROR	OR BY SWI MECHANICAL IN FMEA'S (IS NOT WIT)	LJ TCH OR SHOCK.THE 05-6MA-2037-1 HIN		

THE SCOPE OF THIS TASK. THEREFORE, FMEA 04-1A-0144-4 IS BEING RECOMMENDED FOR DELETION.

THE NASA SUBSYSTEM MANAGER AGREED TO DELETE FMEA 04-1A-0144-4.

REPORT DATE 03/24/87 C

C-75

ASSESSMENT DATE: ASSESSMENT ID: NASA FMEA #:	12/19/86 FCP-170X 04-1A-137-	-1	NASA DATA BASELINE NEW	: [] [X]		
SUBSYSTEM: MDAC ID: ITEM:	EPG 170 LINE FITTI	NGS COMPONENTS				
LEAD ANALYST:	M. HIOTT	M. HIOTT				
ASSESSMENT:						
CRITICAL	ITY RE	DUNDANCY SCREEN	is	CIL		
FLIGH HDW/FUI	r NC A	В	с	ITEM		
NASA [2 /1R IOA [2 /1R] [P]] [P]] [P]] [P]	P] P]	[X] * [*]		
COMPARE [/] [] []	[]	[]		
RECOMMENDATIONS:	(If diff	erent from NAS	A)			
[/] [] []] (AI	[] DD/DELETE)		
* CIL RETENTION H	RATIONALE:	(If applicable)		C V 1		
]	NADEQUATE			
REMARKS:		····		_ · · · · · · · · · · · · · · · · · · ·		
A GROSS EXTERNAL	LEAK AT OR	NEAR THE WATER	R RELIEF PAN	VEL WILL		
CAUSE LOSS OF PRO	DUCT WATER	FROM THE FUEL	CELL TO THI	E ECLSS. A		
GROSS LEAK COULD	SPRAY THE	WATER RELIEF LI	NE AND PROL	DUCT WATER		
LINE TO THE ECLS:	5 WITH WATE	R CAUSING THEM	TO FREEZE	INTERNALLY.		

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REPORT DATE 03/24/87 C-76

THE ALTERNATE WATER PATH TO THE ECLSS WOULD THEN BE USED.

APPENDIX D

CRITICAL ITEMS

	MDAC		
NASA FMEA	ID	ITEM	FAILURE MODE
			-
04-1A-0101-2	108	SEPARATOR PLATES	COOLANT LEAKAGE
04 - 1A - 0101 - 2	130	H2/02 PREHEATER	RESTRICTED COOLANT
01 111 0101 1	100		FI.OW
04-13-0101-2	1 2 1		EVTEDNAL LEAK OF
04-1A-0101-2	TOT	HUTDAL COMPOL VILVE	EXTERNAL LEAR OF
		THERMAL CONTROL VALVE,	TSC COULANT
		CONDENSER, FILTERS,	
		START/SUSTAIN HEATER,	
		ACCUMULATOR	
04-1A-0101-2	132	COOLANT PUMP	LOSS OF OUTPUT
04-1A-0101-2	141	THERMAL CONTROL VALVE	ERRONEOUS OUTPUT
04-1A-0101-3	104	END CELL HEATER	FAIL OFF
04 - 1A - 0101 - 3	138	WATER SEPARATOR PUMP	DEGRADED PERFORMANCE
04 - 12 - 0101 - 3	1 3 9	WATER SEPARATOR	RESTRICTED FLOW
04 111 0101 5	137	DIMD/WATED CONDENSATE	REDIRICIED I EON
		TOMP/WATER CONDENSATE	
04 13 0101 3	140	IRAP WARED DISCULDCE VALVE	ENTE CLOSED
04-1A-0101-3	142	WATER DISCHARGE VALVE	FAIL CLUSED
04-1A-0101-3	143	HZU DISCHARGE LINE	RESTRICTED FLOW
04 - 1A - 0101 - 4	T06	SEPARATOR PLATES/UEA	REACTANT LEAKAGE TO
			ORBITER (EXTERNAL
			LEAKAGE)
04-1A-0101-4	117	H2/O2 LINES AND FITTINGS	REACTANT LEAKAGE TO
		AND ACCESSORY COMPONENTS	ORBITER (EXTERNAL
		_	LEAKAGE)
04-1A-0101-5	101	FUEL CELL	LOSS ELECTRICAL
			CONTACT IN THE
			POWER SECTION
04-18-0101-6	105	END CELL HEATER	FATL ON
04 - 12 - 0101 - 7	113	INTEGRATED DILAL GAS	H2 STARVATION
04 IR 0101 /	110	DECILIATION	IIZ DIANVALION
04 18 0101 7	115	THEOLAIOR	
04-1A-0101-7	115	INTEGRATED DUAL GAS	02 STARVATION
		REGULATOR	
04-1A-0101-8	$\bot \bot \bot$	INTEGRATED DUAL GAS	GRUSS VENTING
		REGULATOR	
04-1A-0101-9	107	SEPARATOR PLATES/UEA	INTERNAL LEAKAGE
04-1A-0104-1	118	02/H2 PURGE-VENT LINES	RESTRICTED FLOW
		AND VENT NOZZLES	
04-1A-0105-1	118	02/H2 PURGE-VENT LINES	RESTRICTED FLOW
		AND VENT NOZZLES	
04-1A-0106-1	165	WATER NOZZLE	RESTRICTED FLOW
04 - 12 - 0106 - 2	163	WATER NOZZLE HEATER	FATL OFF
04 111 0100 2	100	(ACB)	TATE OFF
		(ACD)	
	110		
04-1A-010/-1	TTO	ND VENE NORE PC	KEDIKICIED EEOM
		AND VENT NUZZLES	
04-1A-0108-1	TT8	UZ/HZ PURGE-VENT LINES	RESTRICTED FLOW
		AND VENT NOZZLES	
04-1A-0109-1	159	WATER RELIEF (VENT) LINE	RESTRICTED FLOW

NASA FMEA	MDAC ID	ITEM	FAILURE MODE
04-1A-0119-2	153	WATER RELIEF VALVE	FAILS OPEN
04-1A-0119-3	152	WATER RELIEF VALVE	EXTERNAL LEAKAGE
04-1A-0122-1	151	WATER SUPPLY CHECK VALVE	FAILS TO CHECK
04-1A-0136-1	148	PRODUCT WATER LINE	RESTRICTED FLOW (EXTERNAL LEAKAGE)
04-1A-0136-2	148	PRODUCT WATER LINE	RESTRICTED FLOW (EXTERNAL LEAKAGE)
04-1A-0150-1	164	WATER RELIEF NOZZLE TEMPERATURE SENSOR	ERRONEOUS OUTPUT
04-1A-0150-2	164	WATER RELIEF NOZZLE TEMPERATURE SENSOR	ERROENOUS OUTPUT
04-1A-0137-1	170	LINE FITTINGS COMPONENTS	GROSS EXTERNAL LEAKAGE

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APPENDIX E DETAILED ANALYSIS

This appendix contains the IOA analysis worksheets supplementing previous results reported in STSEOS Working Paper 1.0-WP-VA86001-10, Analysis of the EPG/FCP, (05 December 1986). Prior results were obtained independently and documented before starting the FMEA/CIL assessment activity. Supplemental analysis was performed to address failure modes not previously considered by the IOA. Each sheet identifies the hardware item being analyzed, parent assembly and function performed. For each failure mode possible causes are identified, and hardware and functional criticality for each mission phase are determined as described in NSTS 22206, Instructions for Preparation of FMEA and CIL, 10 October 1986. Failure mode effects are described at the bottom of each sheet and worst case criticality is identified at the top.

LEGEND FOR IOA ANALYSIS WORKSHEETS

Hardware Criticalities:

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- 1 = Loss of life or vehicle
 - Loss of mission or next failure of any redundant item (like or unlike) could cause loss of life/vehicle
- 3 = All others

Functional Criticalities:

- 1R = Redundant hardware items (like or unlike) all of which, if failed, could cause loss of life or vehicle.
- 2R = Redundant hardware items (like or unlike) all of which, if failed, could cause loss of mission.

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Redundancy Screen A:

- 1 = Is Checked Out PreFlight
- 2 = Is Capable of Check Out PreFlight
- 3 = Not Capable of Check Out PreFlight
- NA = Not Applicable

Redundancy Screens B and C:

- P = Passed Screen
- F = Failed Screen
- NA = Not Applicable

DATE:12/18/86HIGHEST CRITICALITYHDW/FUNCSUBSYSTEM:EPGFLIGHT:3/3MDAC ID:166ABORT:3/3

ITEM: COOLANT RETURN TEMPERATURE SENSOR FAILURE MODE: FAIL OPEN OR SHORTED

LEAD ANALYST: M. HIOTT SUBSYS LEAD: M. HIOTT

BREAKDOWN HIERARCHY:

1) EPG 2) FCP 3) ASA 4) TCS 5) 6) 7) 8) 9)

> CRITICALITIES FLIGHT PHASE HDW/FUNC ABORT HDW/FUNC RTLS: 3/3 PRELAUNCH: 3/3 3/3 TAL: LIFTOFF: 3/3 3/3 AOA: 3/3 ONORBIT: 3/3 ATO: 3/3 DEORBIT: LANDING/SAFING: 3/3

REDUNDANCY SCREENS: A [NA] B [NA] C [NA]

LOCATION: MID-BODY PART NUMBER: ME449-0160-0003

CAUSES: VIBRATION, MECHANICAL SHOCK, CORROSION

EFFECTS/RATIONALE:

A FAILED TEMPERATURE SENSOR CAUSES LOSS OF MEASUREMENT. THE FAILURE CAN BE DETERMINED BY A CONSTANT LOW OR HIGH SCALE. A NORMAL STACK OUTLET TEMPERATURE AND A NORMAL CONDENSER EXIT TEMPERATURE CAN BE USED TO INDICATE A NORMAL COOLANT RETURN TEMPERATURE.

REFERENCES:

DATE: 12/18/86 SUBSYSTEM: EPG MDAC ID: 167	HIGHEST CRITICALITY HDW/FUNC FLIGHT: 3/3 ABORT: 3/3
ITEM: COOLANT RETURN TEMPE FAILURE MODE: ERRONEOUS OUTPUT	ERATURE SENSOR
LEAD ANALYST: M. HIOTT SUBSYS	S LEAD: M. HIOTT
BREAKDOWN HIERARCHY: 1) EPG 2) FCP 3) ASA 4) TCS 5) 6) 7) 8) 9)	
CRITICAL	LITIES
FLIGHT PHASEHDW/FUNCPRELAUNCH:3/3LIFTOFF:3/3ONORBIT:3/3DEORBIT:3/3LANDING/SAFING:3/3	ABORT HDW/FUNC RTLS: 3/3 TAL: 3/3 AOA: 3/3 ATO: 3/3
REDUNDANCY SCREENS: A [NA]	B [NA] C [NA]
LOCATION: MID-BODY PART NUMBER: ME449-0160-0003	i i i a circa cara a ser e e e e e e e e e e e e e e e e e e
CAUSES: VIBRATION, MECHANICAL SHOO	CK, CORROSION
EFFECTS/RATIONALE: A FAILED TEMPERATURE SENSOR CAUSES STUCK OUTLET TEMPERATURE AND A NORM CAN BE USED TO INDICATE A NORMAL CO FAILING TEMPERATURE SENSOR.	LOSS OF MEASUREMENT. A NORMAL MAL CONDENSOR EXIT TEMPERATURE OOLANT RETURN TEMPERATURE AND A
REFERENCES:	- *- · ·

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DATE: 12/18/86	HIGHEST	CRITICALITY	HDW/FUNC
SUBSYSTEM: EPG		FLIGHT:	3/3
MDAC ID: 168		ABORT:	3/3
ITEM: FCP PRODUCT WATER LI	NE HEATEN	R	ION
FAILURE MODE: INADVERTENTLY TURNED	ON DURIN	NG FCP OPERAT	
LEAD ANALYST: M. HIOTT SUBSYS	LEAD: M	. HIOTT	
BREAKDOWN HIERARCHY: 1) EPG 2) FCP 3) ASA 4) WRS 5)			

6)

7) 8)

9)

	CRITIC	ALITIES	
FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/3
LIFTOFF:	3/3	TAL:	3/3
ONORBIT:	3/3	AOA:	3/3
DEORBIT:	3/3	ATO:	3/3
LANDING/SAFING:	3/3		
REDUNDANCY SCREENS:	A [NA]	B [NA]	C [NA]

LOCATION: MID-BODY PART NUMBER: MC363-0038-0006

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CAUSES: VIBRATION, MECHANICAL SHOCK, ACCELERATION, SWITCH FAILURE, THERMOSTAT FAILURE

EFFECTS/RATIONALE:

THIS FAILURE CAN OCCUR ONLY BY CREW ACTION OR BY SWITCH OR THERMOSTAT FAILURE CAUSED BY VIBRATION OR MECHANICAL SHOCK. THE SWITCH AND THERMOSTAT HAVE BEEN EVALUATED IN FMEAS 05-6MA-2037-1 AND 04-1A-0151-1 RESPECTIVELY. CREW ERROR IS NOT WITHIN THE SCOPE OF THIS TASK. THEREFORE, FMEA 04-1A-0144-3 IS BEING RECOMMENDED FOR DELETION.

REFERENCES:

DATE: 12/18/86 SUBSYSTEM: EPG MDAC ID: 169	HIGHEST CRITICALITY HDW/FUNC FLIGHT: 3/3 ABORT: 3/3
ITEM: FCP PRODUCT WATER LI FAILURE MODE: BOTH ELEMENTS TURNED	NE HEATER) ON DURING FCP SHUTDOWN
LEAD ANALYST: M. HIOTT SUBSYS	LEAD: M. HIOTT
BREAKDOWN HIERARCHY: 1) EPG 2) FCP 3) ASA 4) WRS 5) 6) 7) 8) 9)	
CRITICAL	TTTES
FLIGHT PHASE HDW/FUNC	ABORT HDW/FUNC
PRELAUNCH: 3/3	RTLS: 3/3
LIFTOFF: 3/3	TAL: 3/3
ONORBIT: 3/3	AOA: 3/3
DEORBIT: 3/3	ATO: 3/3
LANDING/SAFING: 3/3	,
REDUNDANCY SCREENS: A [NA]	B [NA] C [NA]
LOCATION: MID-BODY	
PART NUMBER: MC363-0038-0006	
CAUSES: VIBRATION, MECHANICAL SHOO	CK, SWITCH FAILURE
EFFECTS/RATIONALE: THIS FAILURE CAN OCCUR ONLY BY CREW THERMOSTAT FAILURE CAUSED BY VIBRAT	ACTION OR BY SWITCH OR TION OR MECHANICAL SHOCK. THE

SWITCH AND THERMOSTAT HAVE BEEN EVALUATED IN FMEAS 05-6MA-AND 04-1A-0151-1 RESPECTIVELY. CREW ERROR IS NOT WITHIN THE SCOPE OF THIS TASK. THEREFORE, FMEA 04-1A-0144-4 IS BEING RECOMMENDED FOR DELETION.

REFERENCES:

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REPORT DATE 01/23/87 E-5

HIGHEST CRITICALITY HDW/FUNC DATE: 12/19/86 FLIGHT: 2/1R SUBSYSTEM: EPG 2/1R ABORT: MDAC ID: 170 ITEM: LINE FITTINGS COMPONENTS

FAILURE MODE: EXTERNAL LEAKAGE

LEAD ANALYST: M. HIOTT SUBSYS LEAD: M. HIOTT

BREAKDOWN HIERARCHY:

1) EPG 2) FCP 3) ASA 4) WRS 5) 6) 7) 8)

9)

	CRITICA	LITIES	
FLIGHT PHASE	HDW/FUNC	ABORT	HDW/FUNC
PRELAUNCH:	3/3	RTLS:	3/1R
LIFTOFF:	2/1R	TAL:	3/1R
ONORBIT:	2/1R	AOA:	3/1R
DEORBIT:	3/1R	ATO:	2/1R
LANDING/SAFING	: 3/3		

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REDUNDANCY SCREENS: A [1] B [P] C [P]

LOCATION: MID-BODY PART NUMBER: V070-454110-124

CAUSES: VIBRATION, MECHANICAL SHOCK, CORROSION

EFFECTS/RATIONALE:

AN EXTERNAL LEAK AT A PRODUCT WATER LINE (BEFORE THE WATER RELIEF PANEL) CAUSES LOSS OF PRODUCT WATER FROM THE FUEL CELL TO THE ECLSS. THE FUEL CELL WOULD BE SHUTDOWN DUE TO THE POSSIBILITY OF FREEZING THE LINE. A LEAK COULD SPRAY THE TWO REMAINING PRODUCT WATER LINES CAUSING THEM TO FREEZE INTERNALLY. THIS WOULD RESULT IN FLOODING OF ALL FUEL CELLS.

REFERENCES:

APPENDIX F

NASA FMEA TO IOA WORKSHEET CROSS REFERENCE/RECOMMENDATIONS

This section provides a cross reference between the NASA FMEA and corresponding IOA analysis worksheet(s) included in Appendix E. The Appendix F identifies: NASA FMEA Number, IOA Assessment Number, NASA criticality and redundancy screen data, and IOA recommendations.

Appendix F Resolution/Issue/Rationale Codes

Code Definition

- 1 IOA Issue.
- 2 IOA recommends generating a FMEA for the subject failure mode.
- 3 IOA generated a non-credible failure mode.
- 4 IOA generated a failure mode covered by EPD&/C.

APPENDIX F

IDENT I	FIERS	 N	ASA		IOA RECOM	MENDATIONS *	
NASA FMEA NUMBER	I IOA ASSESSMENT NUMBER	CRIT HW/F	SCREENS A B C	CRIT	SCREENS	OTHER (SEE LEGEND CODE)	issue
	FCP-109	========= /				3	;======= ; ; v
1	FCP-110		i i	; 2/1K		i I, Z I 4	i A
			i i	i /	i 1	i 4 I 2	1
1	1 FUP-124	ii / 11 /	i i r i	i /	i I	13	1
i	; FUP-120 ·			1 /	1		i
i I	FUP-127		i I I I	1 /	r r	1 7 1 A	I I
i I	FCP_120	11 /		1 /	t I	13	1
i t	FCP_133	11 / 11 /	i i	! 3/3	NA NA NA	1.2	i x
1	FCP-134	!! /	!!!	1 3/3	NA NA NA	1. 2	X
1	FCP-135			3/3	NA NA NA	1. 2	X
1	FCP-136			3/3	NA NA NA	1, 2	, X
1	FCP-137			3/3	NA NA NA	1, 2	X
	FCP-144	/		3/3	NA NA NA	1, 2	¦ X
	FCP-146	1 /		1 /		3	l
1	FCP-156			17	1	3	1
1	FCP-161	11 /	!!	/	1	3	ł
1	FCP-162	11 /		1 /	l	; 3	ł
04-1A-0101-2	FCP-108	2/1R	PPP	/	1		1
	FCP-130	2/1R	P P P	/	1	}	1
1	; FCP-131	2/1R	PPP	/		l l	i i
1	FCP-132	2/1R	P P P	/		l l	I
	FCP-141	2/1R	PPP	/	1		
¦ 04-1A-0101-3	FCP-104	2/1R	P P P	/		l 1	1
	FCP-138	2/1R	PPP	/		8	1
	FCP-139	2/1R	PPP	/			
	FCP-142	2/1R	PPP	/			1
	FCP-143	2/1R	PPP				1
¦ 04-1A-0101-4	FCP-106	1/1	NA NA NA				
	FCP-117	1/1	NA NA NA				
04-1A-0101-5	; FCP-101	2/1R	P P P		1		i
04-1A-0101-6	+ FCP-105	2/1R	;		1		i
04-1A-0101-7	; FCP-113	2/1K	;		i	i F	i
	; FUP-115	1 2/ IK	;		i	i I	i r
1 04-1A-0101-8	; FUP-111	2/1K	;	i /	i I	í I	1
	1 FCD 117	ii ∠/1K ⊔ 2/10	ומסם		i t	i 1	1
i L 04 14 0101 0	1 FOP-114	∠/IK 1/1	1 F F F i I NA NA NA I	1 /	1 1	8	1
1 04-1A-0101-9	FCD_119	11 1/1 11 2/10	іпапапа; IDDDI	1 /	1 1	1	1
1 04-1A-0104-1		11 2/11 11 2/10		1 /	1	1 1	i i
1 04-1A-0100-1	1 FCD_165	11 2/11 11 2/110		1 /	1	1	i
1 UH-1A-0100-1	1 100-100	∠⁄116 	1 FINAT 	1 /	1	∎ !	1
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NASA FMEA TO IOA WORKSHEET CROSS REFERENCE/RECOMMENDATIONS

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IDI	ENTIFIERS	NAS	A I	1	IOA RECOM	ENDATIONS *	
NASA FMEA NUMBER	IOA ASSESSMENT NUMBER	CRIT HWI/F	SCREENS	CRIT	SCREENS A B C	OTHER (SEE LEGEND CODE)	ISSU
04-1A-0106-2	FCP-163	2/1R	PNAP	/	• • • • • • • • • • • • • • • • • • •		1
04-1A-0107-1	FCP-1188	2/1R	P P P ¦	/	1		ł
04-1A-0108-1	FPC-118C	2/1R	P	/	-		1
04-1A-0109-1	FCP-159	2/1R	PNAP	/			ł
04-1A-0119-1	FCP-154	3/1R	PNAP	/	1		1
04-1A-0119-2	FCP-153	2/2	NA NA NA 🛔	/		1	1
04-1A-0119-3	FCP-152	2/2	NA NA NA	/	1		ł
04-1A-0122-1	FCP-151	3/2R	PFP	/			
04-1A-0122-2	FCP-150	3/1R	P P P ;	/			!
04-1A-0122-3	FCP-149	3/1R	PPP	/			1
04-1A-0125-1	FCP-157	3/3	NA NA NA	/	1		1.
04-1A-0125-2	FCP-157A	3/3	NA NA NA	/			1
04-1A-0128-1	FCP-166X	3/3	NA NA NA	/	1		
04-1A-0128-2	FCP-167X	3/3	NA NA NA 🛔	/	1		!
04-1A-0131-1	FCP-119	3/3	NA NA NA	/	1		1
04-1A-0131-2	FCP-120	3/3	NA NA NA	/	1		1
04-1A-0132-1	FCP-121	3/3	NA NA NA	/	1		1
04-1A-0132-2	FCP-122	3/3	NA NA NA 🛔	/	1		ł
04-1A-0133-1	FCP-158	3/3	NA NA NA 🛔	/	1		ł
04-1A-0133-2	FCP-158A	3/3	NA NA NA	/			ł
04-1A-0136-1	FCP-148	2/1R	P P P ;	/			ł
04-1A-0136-2	FCP-148A	2/1R	P P P	/	1		-
04-1A-0138-1	; FCP-155	3/1R	P NA P	/		í T	1
04-1A-0141-1	FCP-160	3/1R	PPP	/	1	1	ł
04-1A-0142-1	FCP-123	3/1R	P P P ¦	/	1		1
04-1A-0143-1	; FCP-125	3/1R	PPP	/	1		1
04-1A-0144-1	; FCP-147	3/3	NA NA NA 🛔	/	1		i i
04-1A-0144-3	FCP-168X	3/3	na na na ¦	/	1		ł
04-1A-0144-4	FCP-169X	3/3	na na na ¦	/			ł
04-1A-0149-1	FCP-125B	3/1R	PPP	/			1
04-1A-0150-1	FCP-164	2/1R	P P P	/			1
04-1A-0150-2	FCP-164A	2/1R	P	/	1 1		1
04-1A-0151-1	FCP-145	3/3	NA NA NA ¦	/			!
04-1A-137-1	FCP-170X	1/1	NA NA NA ¦	/	1		:
	1		ł	1			ł

F-3