

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL HARDWARE

NUMBER: 03-1-0661 -X

SUBSYSTEM NAME: D&C - MAIN PROPULSION**REVISION:** 1 02/22/01

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: D&C PANEL F7A7	
LRU	:METER	MC432-0232-0012

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

METER, LO2/LH2 ENGINE MANIFOLD PRESSURE.

REFERENCE DESIGNATORS: 34V73A7A7M2A
34V73A7A7M2B.

QUANTITY OF LIKE ITEMS: 1**FUNCTION:**

INDICATES LO2 AND LH2 ENGINE MANIFOLD PRESSURE IN PSIA.

RANGES: LO2 - 0 TO 300 PSIA IN 50-PSI INCREMENTS.

LH2 - 0 TO 100 PSIA IN 10-PSI INCREMENTS.

FAILURE MODES EFFECTS ANALYSIS FMEA -- NON-CIL FAILURE MODE

NUMBER: 03-1-0661-01

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LRU: D&C PANEL F7A7

ITEM NAME: MPS ENGINE MANF PRESSURE METER

CRITICALITY OF THIS

FAILURE MODE: 1R3

FAILURE MODE:

INACCURATE READING.

MISSION PHASE:

LO LIFT-OFF
OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
105 ENDEAVOUR

CAUSE:

PIECE PART STRUCTURAL FAILURE, CONTAMINATION, VIBRATION, MECHANICAL SHOCK,
PROCESSING ANOMALY.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS
B) N/A
C) PASS

PASS/FAIL RATIONALE:

A)

B)

METER IS STANDBY REDUNDANT TO DUMP FAILURES

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

INACCURATE INDICATION OF LH2/LO2 MANIFOLD PRESSURE.

(B) INTERFACING SUBSYSTEM(S):

NO EFFECT - FIRST FAILURE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

(C) MISSION:

SAME AS B.

(D) CREW, VEHICLE, AND ELEMENT(S):

SAME AS B.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/3 3 SUCCESS PATHS. TIME FRAME - POST DUMP AND PRE VACUUM INERT.

- 1) INCOMPLETE MPS DUMP, I.E. LH2 TOPPING VALVE (PV13) FAILS TO REMAIN OPEN.
- 2) LH2 MANIFOLD RELIEF SYSTEM FAILS TO RELIEVE.
- 3) INACCURATE READING OF LO2/LH2 ENGINE MANIFOLD PRESSURE METER (M3).

CREW USES METER TO DETERMINE WHICH PROPELLANT MANIFOLD REQUIRES IMMEDIATE VACUUM INERTING. INACCURATE METER READING COULD DELAY OR PREVENT TIMELY CORRECTIVE ACTION. PRESSURE BUILDUP DUE TO RELIEF SYSTEM FAILURE WILL CAUSE MANIFOLD RUPTURE RESULTING IN LEAKAGE OF PROPELLANT INTO THE AFT COMPARTMENT. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

PHYSICAL/FUNCTIONAL DESCRIPTION

TAPE METER CONFIGURATIONS DIFFER IN METER MOVEMENT RANGE, SCALE INDICATION, AND NUMBER OF DISPLAYS. EACH TAPE METER IS A PANEL MOUNTED ELECTRONIC INDICATOR CONSISTING OF A SINGLE OR MULTIPLE-FIXED VERTICAL SCALE METER FACE WITH DUAL, TRIPLE, OR QUADRUPLE TAPE MOVEMENTS. THE METERS CONTAIN INTEGRAL LIGHTING, OPERATE FROM A 28 VOLT (DC) POWER SOURCE AND PROVIDE INDICATION FROM A 0 TO 5 VOLT (DC) ANALOG INPUT SIGNAL.

THE ELECTRONIC/MECHANICAL ASSEMBLY IS ENCLOSED IN A SEALED ENVELOPE, TAPE METERS ARE USED IN THE ORBITER FOR DISPLAY PURPOSES. THEY PRESENT VISUAL INFORMATION ON SELECTED PARAMETERS USING SERVO DRIVEN TAPES. TAPE METERS PROVIDE INDICATION OF DISCRETE PRESSURE, QUANTITY, AND TEMPERATURE PARAMETERS WITHIN THE MAIN PROPULSION, HYDRAULIC AND AUXILIARY POWER SUBSYSTEMS.

DESIGN EVOLUTION

DURING THE SUPPLIER MANUFACTURING PHASE VARIOUS DESIGN PROBLEMS AND FAILURES OCCURRED WHICH RESULTED IN CORRECTION ACTION IN AREAS OF FABRICATION PROCESSES AND CONTROLS DESIGN IMPROVEMENTS AND ADDED INSPECTION POINTS. DESIGN IMPROVEMENTS RESULTED IN PART NUMBERS CHANGES. THE MC432-0232-0013;014 AND -0010 CONFIGURATION WERE USED FOR QUALIFICATION AND OV101 CERTIFICATION (THESE ARE REPRESENTATIVE OF ALL METER CONFIGURATIONS).

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

THE MC432-0232-0023, 0025, -0026 AND -0027 WERE OV101 ALT UNITS, FORMERLY -0003,5,6 AND 7 UNITS, FINAL USED IN SAIL.

ACCUMULATION OF CORRECTIVE/REMEDIAL ACTIONS LEAD TO THE MODIFICATION OF THE - 0013, 0014 AND -0016 CONFIGURATION FLIGHT METERS IDENTIFIED WITH PART NUMBERS MC432-0232-0008,9,10,11,12,15,17 AND -0018 WERE ALSO MODIFIED. THESE MODIFICATIONS WHICH CONSISTED OF CHANGING BONDING MATERIALS FOR ADHERE OF TAPE TO DRUMS, RE-ROUTING OF WIRE, WIRE RESTRAINTS AND STRESS RELIEF ADDED TO PREVENT WIRE BREAKAGE, MECHANICAL INTERFERENCE TO METER CORRECTED BY MACHINING IMPROVEMENT AND ELIMINATING SPOT WELDING WITHIN THE UNITS. NOTE - TEST SPECIMENS DID NOT HAVE OPPL APPROVED PARTS. ALL FLIGHT UNITS USE JANTXV QUALITY LEVEL ELECTRONIC PARTS.

(B) TEST:

CERTIFICATION

THE TAPE METER MOVEMENT RANGE AND SCALE INDICATIONS DIFFER. THE TEST SPECIMENS SELECTED REPRESENTED ALL CONFIGURATIONS AS CLOSELY AS POSSIBLE AND ARE CONSIDERED SIMILAR. THE TAPE METERS WERE CERTIFIED FOR OV101 ALT ON CR-19-432-0232-0013B BY TESTS CONDUCTED ON TEST ARTICLES MC432-0232-0013,-0014 AND -0016. DELTA QUALIFICATION TESTS ON MOD -0013,14 AND 16 UNITS CERTIFIED THE FLIGHT UNITS - 0008,9,10,11,12,15,17,18 PER CERTIFICATION OF CR 19-432-0232-0008, EFFECTIVE ON OV102 THROUGH OV104.

ITEM IDENTIFICATION - TEST ARTICLES AND CERTIFIED METER (FLIGHT) CONFIGURATION AND SIMILARITY. COMPARISON (OV102 AND SUBS).

<u>CERTIFICATION & QUALIFICATION</u> TEST SAMPLE DASH NO.	<u>FLIGHT CERTIFIED</u> SIMILAR DASH NO.	MC432-02320 (TAPE METER) CONFIGURATION/SIMILARITY
-0013	-0008 -0009	1) TRIPLE METER MOVEMENT 2) DIALS ON -0013, -0009, -0017 & -0018 ARE THE SAME 0-100%. 3) THE -0008 HAS A DUAL DIAL INDICATION PSIA AND °F. 4) CONNECTOR IS NON-OPPL HARDWARE ON TEST UNIT.
-0014	-0010	1) QUADRUPLE METER MOVEMENT WITH DUAL SCALE INDICATIONS. 2) CONNECTOR IS NON-OPPL HARDWARE ON TEST UNIT.
-0016	-0011 -0012	1) DUAL METER MOVEMENT. 2) DIFFERENT SCALE INDICATIONS. 3) CONNECTOR IS NON-OPPL HARDWARE ON TEST UNIT.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

QUALIFICATION TESTS

TEST

TEST
ACCEPTANCE TEST
VIBRATION
QAVT - (0.067G ² /HZ)
FLIGHT - (0.9G ² /HZ)
ACCELERATION
SHOCK
BENCH HANDLING
BASIC DESIGN
CRASH SAFETY
WINDOW IMPACT
BONDING
ELECTROMAGNETIC COMPATIBILITY (EMC)
THERMAL CYCLE
OPERATING LIFE
POWER TEST
CABIN ATMOSPHERE
PACKAGE QUALIFICATION TEST
LIGHTNING TEST
LIGHTING

ACCEPTANCE TESTS

ALL PRODUCTION METERS ARE SUBJECTED THE FOLLOWING ACCEPTANCE TESTS.

INSPECTION AND TESTS
EXAMINATION OF PRODUCT
FUNCTIONAL TEST
ACCEPTANCE VIBRATION TESTS (0.04G ² HZ)
ACCURACY
ACCEPTANCE THERMAL TESTS
INSULATION RESISTANCE
PRESSURE/VACUUM/LEAK RATE
LIGHTING

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RECEIVING INSPECTION VERIFIES PURCHASED MATERIALS TO THE EXTENT NECESSARY TO ASSURE CONFORMANCE TO THE APPLICABLE TECHNICAL REQUIREMENTS OF THE PURCHASE ORDER AND DRAWING, PER DOCUMENTED POLICY.

ENGINEERING SPECIFIES CRITICAL AND MAJOR PARAMETERS OF PURCHASED PARTS AND MATERIALS TO BE VERIFIED BY RECEIVING INSPECTION, PER DOCUMENTED REQUIREMENTS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

ALL CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED WITH THE ORIGINAL RECEIVING REPORT AND PACKING SLIP.

COMPLETED RECEIVING REPORTS ARE MAINTAINED IN THE CLOSED PURCHASE ORDER FILE PER DOCUMENTED PROCEDURES.

CONTAMINATION CONTROL

QUALITY ASSURANCE (QA) MONITORS AND AUDITS SHOP AREAS TO ENSURE THAT THE RESPONSIBLE PARTIES ARE IN COMPLIANCE WITH ALL SPECIFIED CONTAMINATION CONTROLS, PER DOCUMENTED INSTRUCTIONS.

ASSEMBLY/INSTALLATION

IN-PROCESS INSPECTION POINTS ARE ESTABLISHED BY QA TO ENSURE ACCEPTABILITY OF ITEMS PRIOR TO SUBSEQUENT PROCESSING OR STOCKING, WHEN SUCH PROCESSING WOULD MAKE VERIFICATION OF ACCEPTABILITY OF PREVIOUS OPERATIONS IMPOSSIBLE, PER DOCUMENTED INSTRUCTIONS.

A CRIMP LOG IS MAINTAINED, AND CRIMP TOOL CALIBRATION VERIFICATION COMPLIES WITH MSC-SPEC-Q-1A.

ALL BRAZED JOINTS AND CRIMPS ARE VISUALLY INSPECTED.

CRITICAL PROCESSES

PROCESSING OPERATIONS ARE MONITORED FOR COMPLIANCE WITH QUALITY REQUIREMENTS, AND QA PERFORMS AUDITS TO VERIFY THAT PROCESSING REQUIREMENTS ARE MET.

CRITICAL PROCESSES ARE BRAZING, CRIMPING, SPOT WELDING, SOLDERING, SWAGING, COMPONENT BONDING, CONFORMAL COATING, SEALING, AND ETCHING.

CERTIFICATION OF OPERATORS IS VERIFIED FOR CRIMPING, SOLDERING, COMPONENT BONDING, CONFORMAL COATING, AND HARNESS/CABLE FABRICATION.

TESTING

QA REGULARLY CONDUCTS SURVEILLANCE OF PRODUCT TESTING IN ACCORDANCE WITH DOCUMENTED INSTRUCTIONS.

A PULL TEST IS PERFORMED FOR EVERY ONE HUNDRED SPOT WELDS.

HANDLING/PACKAGING

PARTS PACKAGED AND PROTECTED ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS.

SPECIAL HANDLING PER DOCUMENTED INSTRUCTIONS IS VERIFIED, TO PRECLUDE DAMAGE, SHOCK, AND CONTAMINATION DURING COMPONENT HANDLING/TRANSPORTING/PACKAGING BETWEEN WORK STATIONS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

CONTROLS ARE IMPLEMENTED TO PREVENT ELECTROSTATIC DISCHARGE, AND THE MAINTENANCE OF CONTROLS IS AUDITED BY QA.

(D) FAILURE HISTORY:

CAR-A3322

DURING ACCEPTANCE TEST, THE INPUT CURRENT WAS EXCESSIVE ON CHANNEL 2, TAPE METER (MC432-0232-0003). FAILURE ANALYSIS FOUND SHORTED CAPACITOR RESULTING FROM INTERNAL HOT-SPOT CAUSING BREAKDOWN. THE CAPACITOR (C1) FAILURE WAS ATTRIBUTED TO AN IMPROPER TERMINAL CONNECTION WITHIN CAPACITOR. PRIOR HOT SPOTS WERE EXPERIENCED ON SAME CAPACITOR TYPE WITH WRONG TERMINAL CONNECTION. SUPPLIER'S CORRECTIVE ACTION WAS TO UPGRADE THE C1 TO AN S-LEVEL CAPACITOR (X-RAYED BY MANUFACTURER TO DETECT THIS POTENTIAL DEFECT) EFFECTIVE TO OV102 AND SUBS. PREVIOUS DELIVERED METERS (NON-FLIGHT UNITS) WERE NOT BEING MODIFIED SINCE THEY ARE ACCEPTABLE FOR THEIR INTENDED USE (ADL, SAIL, APU SYSTEM TEST, QUAL TEST AND OV101).

CAR-AB6906 PRIME, CAR-AB7315, CAR-AC1172-REFERENCE

DURING SAIL SYSTEMS CHECKOUT TESTS, IT WAS OBSERVED METER-M4 (MC432- 0232-0010) MOVEMENT WAS ERRATIC. A SIMILAR PROBLEM OCCURRED ON -0018 METER, CAR AB7315. BOTH METERS EXHIBITED EVIDENCE OF OVERHEATING, COMPONENT OVER-STRESS AND APPARENT EXCESSIVE CURRENT DRAW THROUGH THE MOTOR CIRCUITS. BOTH SAIL METERS HAD OPERATED SATISFACTORY FOR OVER 2000 HOURS BEFORE FAILURE DETECTION. THE FAILURE ANALYSIS DETERMINED THE FAILURES WERE ATTRIBUTED TO DEFECTIVE MOTOR ARMATURE WINDING. DUE TO THE SEVERITY OF DAMAGE, THE SPECIFIC CAUSE WAS NOT DETERMINED, BUT BELIEVED TO BE EITHER INSUFFICIENT INSULATION OR DEFECTIVE WINDING DURING MANUFACTURING PROCESS, WHICH DETERIORATED WITH TIME/OPERATION UNTIL INSULATION FAILURE AND A SHORT OCCURRED. IN LIEU OF FACT, THE SAIL METERS EXCEEDED THEIR OPERATIONAL LIFE BEFORE FAILURE, THE SUPPLIER CORRECTIVE ACTION WAS INITIATED TO ELIMINATE DOWNSTREAM POTENTIAL WINDING FAULTS WITHIN THE DRIVE MOTORS DURING THEIR MANUFACTURING PHASE. ARMATURE DIELECTRIC STRENGTH TEST AT 500 VDC ARE TO BE REPEATED THROUGHOUT-MANUFACTURING IN PROGRESS PHASES, UP TO FINAL ASSEMBLY. ALL SHUTTLE ARMATURES WILL BE 100% TESTED FOR INSULATION BREAKDOWN AT THE HIGHEST LEVEL AT WHICH TESTS CAN BE APPLIED. ARMATURE THERMAL TEST WAS REVISED FOR 25 CYCLES BETWEEN -50 DEG. C TO +120 DEG. C WAS FORMERLY -4 DEG C TO +90 DEG. C.

TAPE METERS INSTALLED ON OV102 ARE SATISFACTORY FOR THEIR INTENDED USAGE. THIS WAS BASED UPON THE FACT THAT METERS INSTALLED IN 'SAIL' OPERATED PROPERLY FOR OVER 2000 HOURS. OV102 METERS WERE SCHEDULED FOR 15 MINUTES OPERATION DURING BOOST AND RE-ENTRY.

CAR-A4327 PRIME, CAR-A4248

DURING QUAL VIBRATION TEST, THE TAPE METER (MC432-0232-0013) CHANNEL 2 FLAGGED OFF (TAPE DROPPED PASS ZERO). ANALYSIS DISCLOSED A BROKEN WIRE CAUSED BY INSUFFICIENT RESTRAINT OF WIRE BUNDLES DURING VIBRATION. SUPPLIER'S CORRECTIVE ACTION INCLUDED THE SEPARATION AND REROUTING OF WIRE BUNDLES TO BACK SIDE OF PRINTED CIRCUIT BOARDS USING EXISTING SLOTS FOR THROUGH WIRES NEAR

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

TERMINATION POINTS: ADDITIONAL HOLES WERE MADE AVAILABLE FOR MORE SPOT-TIE ATTACH POINTS. PRINT CIRCUIT BOARDS WERE RE-ARRANGED AND STACKED USING SPACERS FOR IMPROVED WIRE ROUTING. THE SUPPLIER DRAWING WERE REVISED TO SUPPORT THE CHANGES.

THE CHANGES WERE EFFECTIVE ON OV102 AND SUBS, INCLUDING OV101 (OPR) AND WERE IDENTIFIED BY NEW PART NUMBERS -0008, 0009, -0010, -0011, - 0012, -0015, -0017 AND -0018, OV101 ALT UNITS (-0023, -0025, -0026, AND 0027) WERE NOT MODIFIED BECAUSE THEY WOULD NOT BE EXPOSED TO FLIGHT VIBRATION, BUT HAD SATISFACTORILY PASSED ACCEPTANCE WHICH INCLUDED VIBRATION TEST. FURTHER, THE QUAL UNITS PASSED QAVT WITH THE SAME WIRE ROUTING AS OV1-1 ALT-UNITS. QAVT VIBRATION LEVELS ARE HIGHER THAN THOSE ANTICIPATED FOR OV101 ALT. CAR-A4248 WAS A SIMILAR PROBLEM WITH SAME CLOSEOUT.

CAR-A3680 PRIME, CAR-A3679

DURING ACCEPTANCE VIBRATION TEST, TAPE METER (MC432-0232-0005) READOUT CHANGED FROM CALIBRATION POSITION. FAILURE ANALYSIS REVEALED BROKEN SPOT WELDS BETWEEN ARMATURE PLATE AND SHAFT WHICH ALLOWED SLIPPAGE, RESULTING IN CALIBRATION CHANGE. THE SUPPLIER REVISED HIS PLATE AND SHAFT ASSEMBLY DRAWING TO PROVIDE SUITABLE SPOT WELDS WHICH WILL BE SUBJECTED TO 1000 LBS. SHEAR TEST (WAS 60 LBS.) AND THE COMPLETED PARTS TO A 240 LB. PULL TEST (WAS 100 LBS.) FOLLOWED BY INSPECTION FOR SURFACE FLATNESS AND SHAFT PERPENDICULARITY. ALL UNITS NOT SHIPPED TO BE REWORKED AND IDENTIFIED BY NEW PART NUMBERS, OV101 P/N (-0003,5,6 AND 7 CHANGED TO -0023,25,26 AND 27). ALL DELIVERED UNITS WERE NOT TO BE EXPOSED TO VIBRATION OR FLIGHT ENVIRONMENTS (-0003,5,6 AND 7) AND WERE ASSIGNED TO SAIL AND APU SYSTEM TEST. UNITS -1004,5,6 AND 7 WERE ASSIGNED TO ADL. SINCE THE DELIVERED UNITS HAD SUCCESSFULLY PASSES ATP, ATT AND AVT, THEY WERE CONSIDERED SATISFACTORY FOR THE USES NOTED, A SIMILAR FAILURE OCCURRED ON CAR-A3679.

CAR-A3367 PRIME, CAR-A3468, CAR-A3469

DURING ACCEPTANCE VIBRATION TEST, TAPE METER (MC432-0232-0005) BECAME ERRATIC. THE CAUSED WAS ATTRIBUTED TO INSUFFICIENT BRUSH PRESSURE (POTENTIOMETER) AND EXCESSIVE END PLAY OF MOTOR/POTENTIOMETER SHAFT RESULTING IN INTERMITTENT CONTINUITY DURING VIBRATION. THE CORRECT ACTION CONSISTED OF SUPPLIER'S DRAWING CONTROLS TO ASSURE PROPER BRUSH PRESSURE AND ALIGNMENT IN THE POTENTIOMETERS, INCREASE THE GAP BETWEEN WIPER ARM AND RESISTIVE ELEMENT AND ADDITION OF SHIMS FOR SHAFT END PLAY CONTROL. THE SUPPLIER (ELDEC) BUILT NEW TEST FIXTURES TO ASSEMBLE AND INSPECT CHANGES INCORPORATED AND REVISE THEIR MANUFACTURING PLANNING FOR MANDATORY INSPECTION POINTS TO VERIFY THE CHANGES INVOLVED. METERS DELIVERED BEFORE (1-1-76) WERE NON-FLIGHT UNITS, BUT USED IN SAIL (-0003,5,6 AND 7) ADL (-1003,4,5,6 AND 7). UNITS DELIVERED AFTER 1-1-76 WERE IDENTIFIED WITH NEW PART NUMBERS (101 UNITS WERE TO BE -0023, -0025, -0026 AN-0027). FLIGHT UNITS HAD THESE CHANGES INCORPORATED.

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- NON-CIL FAILURE MODE
NUMBER: 03-1-0661-01**

(E) OPERATIONAL USE:

LO2/LH2 MANIFOLD PRESSURE IS ON CAUTION AND WARNING. CREW WILL VERIFY OFF NOMINAL PRESSURE READINGS ON THE PANEL METERS. IF METER IS SUSPECTED TO BE MALFUNCTIONING, CREW CAN ATTEMPT TO CHECK METER READING AGAINST MEASUREMENTS DISPLAYED ON BFS SYS SUMM 1 CRT DISPLAY. IF PRESSURE MEASUREMENTS READ OUT OF NOMINAL RANGE, CREW WILL OPEN THE RESPECTIVE FILL/DRAIN VALVES.

- APPROVALS -

S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
D&C ENGINEERING	: LAITH COTTA	: /S/ LAITH COTTA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
EPD&C SUBSYSTEM MGR.	: RICHARD PHAN	: /S/ RICHARD PHAN
MOD	: JEFF MUSLER	: /S/ JEFF MUSLER
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS