PRINT DATE: 05/07/97

FAILURE MODES EFFECTS ANALYSIS (FMEA) – CIL HARDWARE
NUMBER:M8-1SS-M022 -X

SUBSYSTEM NAME: MECHANICAL - CREW EQUIPMENT
REVISION: 0 06/28/96

PART DATA

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	:TOOL STOWAGE ASSEMBLY	V849-000150-001
SRU	:HINGE ASSEMBLY	V849-000980-001
SRU	:HINGE ASSEMBLY	V849-000990-001

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
TOOL STOWAGE ASSEMBLY (TSA) DOOR HINGE ASSEMBLY

QUANTITY OF LIKE ITEMS: 2
TWO - ONE PER DOOR, TWO DOORS PER TSA

FUNCTION:
THE TSA CONTAINS TWO DOORS, ONE LARGE DOOR AND ONE SMALL DOOR. ATTACHED TO EACH DOOR IS A HINGE ASSEMBLY THAT ALLOWS EASY OPENING AND CLOSING OF THE DOOR.

REFERENCE DOCUMENTS: V849-000610
V849-000710
V849-000980
V849-000990

FAILURE MODES EFFECTS ANALYSIS FMEA – CIL FAILURE MODE
NUMBER: M8-1SS-M022-01

REVISION#: 2 05/08/97

SUBSYSTEM NAME: MECHANICAL - CREW EQUIPMENT
LRU: TOOL STOWAGE ASSEMBLY CRITICALITY OF THIS
ITEM NAME: DOOR HINGE ASSEMBLY FAILURE MODE: 1R2

FAILURE MODE:
JAMMED, INCREASED RESISTANCE

MISSION PHASE: OO ON-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY: 103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:
CONTAMINATION, STRUCTURAL FAILURE DUE TO THERMAL OR MECHANICAL SHOCK, MANUFACTURER/MATERIAL DEFECT, LACK OF LUBRICATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:
A)

B)

C)

METHOD OF FAULT DETECTION:
PHYSICAL OBSERVATION DURING DOOR OPENING/CLOSING.

REMARKS/RECOMMENDATIONS:
EACH DOOR OF THE TSA CONTAINS A SINGLE HINGE ASSEMBLY REQUIRED FOR DRAWING OPENING/CLOSING. WITH EITHER DOOR FULLY OPEN, THE DOOR EXTENSION WILL NOT INTERFERE WITH PROPER CLOSING OF THE PAYLOAD BAY DOORS. THE LARGE DOOR, LOCATED ON THE CENTER COMPARTMENT, CONTAINS ALL THE MISSION SPECIFIC TOOLS WHILE THE SMALL DOOR, LOCATED ON THE FORWARD COMPARTMENT, CONTAINS ALL THE CONTINGENCY TOOLS.

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- FAILURE EFFECTS -

(A) SUBSYSTEM:
PREVENTS MOVEMENT OF THE DOOR IN EITHER THE OPENING OR CLOSING POSITION. AN INCREASE MOMENT OF RESISTANCE COULD BE OVERCOME BY THE FORCE OF OPENING/CLOSING.

(B) INTERFACING SUBSYSTEM(S):
WORST CASE (DURING OPENING) - INABILITY TO OPEN A DOOR WOULD PREVENT USE OF THE TOOLS CONTAINED IN THE AFFECTED COMPARTMENT.

(C) MISSION:
IF FAILURE OCCURS:
DURING OPENING OF LARGER DOOR - UNABLE TO OPEN DOOR TO CENTER COMPARTMENT. INABILITY TO UTILIZE MISSION SPECIFIC TOOLS CONTAINED IN THIS COMPARTMENT MAY AFFECT MISSION COMPLETION - CRITICALITY 2/2 CONDITION.
DURING CLOSING OF EITHER DOOR - INABILITY TO CLOSE A DOOR HAS NO EFFECT ON MISSION SUCCESS SINCE MISSION OBJECTIVES ARE MET WITH COMPARTMENT DOORS OPEN.

(D) CREW, VEHICLE, AND ELEMENT(S):
IF FAILURE OCCURS:
DURING OPENING OF SMALL DOOR - UNABLE TO OPEN DOOR TO FORWARD COMPARTMENT. LOSS OF CAPABILITY TO UTILIZE CONTINGENCY TOOLS CONTAINED WITHIN THIS COMPARTMENT COULD RESULT IN LOSS OF CREW AND VEHICLE IF CONTINGENCY EVA IS REQUIRED.
DURING CLOSING OF EITHER DOOR - AFFECTED DOOR WOULD HAVE TO REMAIN OPEN DURING DE-ORBIT AND LANDING. NO EFFECT SINCE TOOLS WOULD BE REMOVED FROM THE AFFECTED COMPARTMENT.

(E) FUNCTIONAL CRITICALITY EFFECTS:
FIRST FAILURE (DOOR HINGE ASSEMBLY JAMMED IN CLOSED POSITION) - LOSS OF CAPABILITY TO UTILIZE TOOLS CONTAINED WITHIN AFFECTED DOOR COMPARTMENT, INABILITY TO COMPLETE MISSION OBJECTIVES ASSOCIATED WITH THESE ISS TOOLS. - CRITICALITY 2/2 CONDITION
SECOND FAILURE (FAILURE NECESSITATES AN EVA TO CORRECT.A-CRIT 1 CONDITION) - POSSIBLE LOSS OF CREW AND VEHICLE DUE TO THE INABILITY TO CONDUCT AN EMERGENCY EVA BECAUSE EVA TOOLS ARE NOT AVAILABLE FOR USE. - CRITICALITY 1R2 CONDITION

ESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)): 1R2

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(F) RATIONALE FOR CRITICALITY DOWNGRADE:
THERE IS NO CORRECTIVE ACTION TO CIRCUMVENT A HINGE ASSY THAT JAMS DURING DOOR OPENING. CRITICALITY REMAINS AT 1R2.

- TIME FRAME -

TIME FROM FAILURE TO CRITICAL EFFECT: DAYS

TIME FROM FAILURE OCCURRENCE TO DETECTION: IMMEDIATE

TIME FROM DETECTION TO COMPLETED CORRECTING ACTION: N/A

IS TIME REQUIRED TO IMPLEMENT CORRECTING ACTION LESS THAN TIME TO EFFECT?
NO

RATIONALE FOR TIME TO CORRECTING ACTION VS TIME TO EFFECT:
THERE IS NO CORRECTIVE ACTION IF THE SLIDE ASSEMBLY COMPLETELY JAMS AND THE DRAWER CANNOT BE OPENED OR CLOSED.

HAZARD REPORT NUMBER(S): FF-09

HAZARD(S) DESCRIPTION:
INABILITY TO SAFELY PERFORM EVA

-DISPOSITION RATIONALE-

(A) DESIGN:
THE TSA CONTAINS TWO DOORS, A LARGE DOOR (CENTER COMPARTMENT) AND A SMALL DOOR (FORWARD COMPARTMENT). EACH DOOR CONTAINS A SINGLE HINGE ASSEMBLY. THE TWO HINGE ASSEMBLIES ARE MOUNTED SIDE BY SIDE BETWEEN THE TWO DOORS. THE HINGE ON THE FORWARD COMPARTMENT DOOR WILL ALLOW THE DOOR TO SWING DOWN TO OPEN AND THE HINGE ON THE CENTER COMPARTMENT DOOR WILL ALLOW THE DOOR TO SWING UP TO OPEN. DOORS ARE MADE OF 7075 ALUMINUM PLATE AND HINGES ARE MADE OF ALUMINUM ALLOY 2024-T3511. ONE HALF OF THE FORWARD COMPARTMENT DOOR HINGE ASSEMBLY IS BOLTED TO THE TSA USING 10 FASTENERS AND THE SECOND HALF IS BOLTED TO THE DOOR ITSELF USING 19 FASTENERS. ON THE CENTER COMPARTMENT DOOR, ONE HALF OF THE HINGE ASSEMBLY IS BOLTED TO THE TSA USING 11 FASTENERS AND THE OTHER HALF IS BOLTED TO THE DOOR ITSELF USING 21 FASTENERS.

STRUCTURAL LOADS ANALYSIS IS PERFORMED ON THE TSA WHICH INCLUDES THE HINGE ASSEMBLIES - ANALYSIS HAS SHOWN THAT ALL COMPONENTS HAVE OF FACTOR OF SAFETY OF AT LEAST 1.4. REFER TO TSA STRESS ANALYSIS REPORT #SSD95D0466, DATED SEPT 1996, FOR DETAILS.

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(B) TEST:
DOOR HINGE CERTIFICATION - CERTIFICATION OF THE DOOR HINGE ASSEMBLIES WILL BE PERFORMED BY TEST AND ANALYSIS. ANALYSIS DATA WAS PREVIOUSLY ADDRESSED IN THE "DESIGN" SECTION AND TEST DATA IS SHOWN BELOW:

A. TESTING AT NASA (TSA) - DYNAMIC, THERMAL, AND LIFE CYCLE TESTING OF THE TSA AND ITS COMPONENTS IS PERFORMED BY NASA AS FOLLOWS.
1. DYNAMIC TESTING - A RANDOM VIBRATION TEST IS PERFORMED ON FOUR (4) TSA FLIGHT ARTICLES FOR TWO ENVIRONMENTS; FLIGHT VIBRATION AND ACCEPTANCE VIBRATION AS FOLLOWS. FLIGHT VIBRATION LEVELS ARE SHOWN IN THE TABLE BELOW:

20 TO 50 HZ:	+ 5 DB/OCTAVE
50 TO 400 HZ:	0.01 G^2/HZ
400 TO 2000 HZ:	- 4 DB/OCTAVE
GRMS:	3.0
DURATION:	AS DEFINED IN THE NEXT SECTIONS
TEST TOLERANCES:	GRMS = +15%, - 5% G^2/HZ = + 4 DB, - 1 DB

ACCEPTANCE VIBRATION LEVELS ARE SHOWN IN THE TABLE BELOW:

20 TO 80 HZ:	+ 3 DB/OCTAVE
80 TO 350 HZ:	0.04 G^2/HZ
350 TO 2000 HZ:	- 3 DB/OCTAVE
GRMS:	6.1
DURATION:	1.0 MINUTE IN EACH OF X, Y, AND Z AXES
TEST TOLERANCES:	GRMS = +15%, - 5% G^2/HZ = + 4 DB, - 1 DB

TSA NO. 1 RANDOM VIBRATION TEST - WITH TSA FILLED WITH LIMIT DESIGN WEIGHT, RANDOM VIBRATION TEST PERFORMED AT 6 DB BELOW FLIGHT LEVEL ENVIRONMENT FOR A DURATION OF 1.0 MINUTE, IN ALL 3 AXES (X,Y,Z). THEN TSA CONTENTS REMOVED AND TSA EXPOSED TO ACCEPTANCE VIBRATION ENVIRONMENT FOR 1.0 MINUTE IN ALL 3 AXES.
TSA NO. 2 RANDOM VIBRATION TEST - WITH TSA FILLED WITH LIMIT DESIGN WEIGHT, RANDOM VIBRATION TEST PERFORMED AT FLIGHT LEVEL ENVIRONMENT FOR A DURATION OF 16.7 MINUTES, IN ALL 3 AXES.
TSA NO. 3 RANDOM VIBRATION TEST - WITH TSA EMPTY, RANDOM VIBRATION TEST PERFORMED AT ACCEPTANCE VIBRATION ENVIRONMENT FOR 1.0 MINUTE IN ALL 3 AXES.
TSA NO. 4 RANDOM VIBRATION TEST - WITH TSA EMPTY, RANDOM VIBRATION TEST PERFORMED AT ACCEPTANCE VIBRATION ENVIRONMENT FOR 1.0 MINUTE IN ALL 3 AXES.

2. THERMAL CERTIFICATION TESTING - TSA'S WERE SUBJECTED TO THE FOLLOWING THERMAL PROFILE. FIRST, A PRETEST OBJECTIVE FUNCTIONAL TEST (OPENING/CLOSING DRAWERS AND DOORS USING A FORCE GAUGE) WAS PERFORMED AT AMBIENT CONDITIONS. THE CHAMBER TEMPERATURE WAS RAMPED TO -70°F +/-5°F AT A RATE OF 4°F/MIN AND THE TEMPERATURE REMAINED CONSTANT AT -70°F FOR ABOUT 5 MINUTES AND A SUBJECTIVE FUNCTIONAL TEST (OPENING/CLOSING DRAWERS AND DOORS USING THE HAND INSTEAD OF A FORCE GAUGE) WAS PERFORMED. THE CHAMBER TEMPERATURE WAS THEN RAMPED

DOWN TO -125°F +/-5°F AT A RATE OF 4°F/MIN. THE TSA'S WERE SOAKED FOR 30 MINUTES AND THE COLD CASE OBJECTIVE FUNCTIONAL TEST WAS PERFORMED. THEN, THE CHAMBER TEMPERATURE WAS RAMPED UP TO 205°F +/-5°F. THE TSA'S WERE SOAKED AT THIS TEMPERATURE FOR 30 MINUTES AND THE HOT CASE OPERATIVE FUNCTIONAL TEST WAS PERFORMED. LAST, THE CHAMBER TEMPERATURE WAS RETURNED TO AMBIENT CONDITIONS AND A FULL POST OBJECTIVE FUNCTIONAL TEST WAS PERFORMED.
3. LIFE CYCLE TESTING - PRIOR TO PERFORMING THE LIFE CYCLE TEST OF THE DOOR AND HINGES THE FOLLOWING FUNCTIONAL TEST IS PERFORMED: (A) WITH THE TSA RESTING HORIZONTALLY, THE DOORS ARE VERIFIED TO OPEN SMOOTHLY, WITHOUT INTERFERENCE, AND THAT WHEN THE DOORS ARE CLOSED, THEY REST EVENLY ON THE DOOR SUPPORTS; (B) LATCHES AND RECEIVERS FOR THE DOORS ARE VERIFIED TO BE IN ALIGNMENT WHEN THE DOORS ARE CLOSED. (C) EACH LATCH IS OPERATED TO VERIFY ALIGNMENT; AND (D) THE FORCE REQUIRED TO OPEN EACH DOOR IS VERIFIED TO BE WITHIN A 1 TO 5 LB RANGE. EACH DOOR IS CYCLED FROM ITS FULLY CLOSED POSITION TO ITS FULLY OPEN POSITION, AND THEN BACK TO ITS FULLY CLOSED POSITION. THIS CYCLE IS REPEATED A TOTAL OF 400 TIMES. FOLLOWING THIS LIFE CYCLE TEST, VERIFICATION STEPS A, B, C, AND D, AS PREVIOUSLY ADDRESSED, ARE REPEATED.

B. ATP AT BOEING (HINGE ASSEMBLY/LATCHES) - ACCEPTANCE TESTING AT BOEING WILL VERIFY PROPER FUNCTIONING OF THE DOORS AND THEIR COMPONENTS (HINGE ASSEMBLIES/LATCHES) AS FOLLOWS:
1. LATCH TESTING - PRIOR TO THE FUNCTIONAL TEST, ALL LATCHES ARE VERIFIED TO BE IN THEIR LATCHED POSITION. THEN EACH LATCH IS TESTED, IN ANY SEQUENCE, AS FOLLOWS: (A) THE LATCH PAWL IS ROTATED AND THE FOLLOWING IS VERIFIED: THE HANDLE TURNS SMOOTHLY AND THERE IS NO INTERFERENCE BETWEEN THE LATCH AND LATCH HOUSING OR THE LATCH RECEIVER; (B) THE LATCH HANDLE IS POSITIONED AGAINST THE HOUSING AND THE FOLLOWING IS VERIFIED: THE HANDLE IS FIRMLY IN PLACE BY THE SPRING AND THE LATCH/HANDLE IS UNABLE TO MOVE; (C) THE FORCE REQUIRED TO PULL UP THE LATCH HANDLE TO THE VERTICAL POSITION, TAKEN FROM THE CENTER OF GRAVITY OF THE HANDLE, IS VERIFIED TO BE IN THE RANGE OF 5 TO 10 LB; (D) THE FORCE REQUIRED TO PUSH THE LATCH HANDLE IN THE LOCKED POSITION FROM THE CENTER OF GRAVITY IS VERIFIED TO BE IN THE RANGE OF 5 TO 10 LB; (E) AFTER THE LATCH HANDLE IS LIFTED TO ITS VERTICAL POSITION, THE TORQUE REQUIRED TO TURN THE LATCH TO THE UNLOCKED POSITION AND THEN BACK TO THE LOCKED POSITION IS LESS THAN OR EQUAL TO 30IN-LB.
2. DOOR TESTING - DURING OPERATION OF THE DOORS (OPENING AND CLOSING) THE FOLLOWING IS VERIFIED: (A) EACH DOOR OPENS SMOOTHLY WITHOUT INTERFERENCE, WHEN THE DOORS ARE CLOSED THAT THEY REST EVENLY ON THE DOOR SUPPORTS; (B) ALL LATCHES AND RECEIVERS FOR THE DOORS ARE IN ALIGNMENT WHEN THE DOORS ARE CLOSED; AND (C) THE FORCE REQUIRED TO OPEN EACH DOOR IS IN THE 0.5 LB TO 5 LB RANGE, NOT INCLUDING THE WEIGHT OF THE DOOR.

MISSION MANIFEST VERIFICATION - PRIOR TO EACH FLIGHT, THE ORBITER IS CONFIGURED TO SUPPORT A MISSION AS DEFINED IN THE MISSION MANIFEST. AT THIS TIME, IF THE MISSION IS TO SUPPORT ISS, THE TSA WILL BE INSTALLED ON THE EXTERNAL AIRLOCK TRUSS ASSEMBLY AND THE FOLLOWING WILL BE VERIFIED: THE DOORS CAN BE OPENED/CLOSED AND DOOR LATCHES ARE IN THEIR CLOSED AND LOCKED POSITION.

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(C) INSPECTION:
RECEIVING INSPECTION
ALL RECEIVING SLIDE ASSEMBLIES ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION. CLEANLINESS LEVEL GC PER MA0110-301.

ASSEMBLY/INSTALLATION
INSTALLATION OF HINGE ASSEMBLIES PER TSA TOP LEVEL DRAWING V649-000100.

CRITICAL PROCESSES
ANODIZING OF ALUMINUM HINGES INSPECTED PER MIL-A-8625, TYPE II.

NON-DESTRUCTIVE EVALUATION
FLOURESCENT PENETRANT INSPECTION PER MIL-STD-6866, TYPE I, METHOD C, SENSITIVITY LEVEL 3.

TESTING
CERTIFICATION TEST/MISSION MANIFEST CHECKLIST VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING, PACKAGING, STORAGE, AND SHIPPING PROCEDURES VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

(E) OPERATIONAL USE:
<u>DURING DOOR OPENING</u> - THERE IS NO CORRECTIVE ACTION IF A DOOR HINGE ASSEMBLY COMPLETELY JAMS. HOWEVER, AN INCREASE IN RESISTANCE CAN BE OVERCOME BY THE FORCE OF OPENING THE AFFECTED DOOR.
<u>DURING DOOR CLOSING</u> - AN INCREASE IN RESISTANCE CAN BE OVERCOME BY THE FORCE OF CLOSING THE AFFECTED DOOR. IN THE CASE WHERE THE HINGE ASSEMBLY COMPLETELY JAMS, CREW COULD REMOVE THE TOOLS, IN AFFECTED COMPARTMENT, AND STOW THEM WITHIN THE CREW CABIN AREA.

- APPROVALS -

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