

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : ATMOSPHERIC REVIT. FMEA NO 06-1B -0629 -1 REV: 05/02/88

ASSEMBLY : AIR DUCTS CRIT. FUNC: 1
P/N RI : V070-613YYY CRIT. HDW: 1
 : ME276-00XX
 VEHICLE 102 103 104
P/N VENDOR: EFFECTIVITY: X X X
QUANTITY : 1 SET PER VEHICLE PHASE(S): PL LO X OO X DO X LS

PREPARED BY: DES N. K. DUONG
REL N. L. STEISLINGER
QE W. J. SMITH

REDUNDANCY SCREEN: A- B- C-
APPROVED BY: APPROVED BY (NASA):
DES *[Signature]* SSM *[Signature]*
REL *[Signature]* REL *[Signature]*
QE *[Signature]* QE *[Signature]*

ITEM:
DUCT SECTIONS, SINGLE MAIN CABIN RETURN AIR AND IMU OUTLET AIR

FUNCTION:
1. COLLECT AIR FROM FLIGHT DECK BRANCHES OF CABIN AIR RETURN DUCTING AND DIRECT IT TO THE THREE MAIN RETURN DUCTS ON THE STARBOARD SIDE.
P/N'S: ME276-0024 (QTY 6), V070-613693, 694, 695, 778, 784, 785, 786.
2. COLLECT AIR FROM THE THREE IMU OUTLETS AND DIRECT IT TO THE IMU FAN INLET. P/N'S: V070-613427, 553, 557.

FAILURE MODE:
EXTERNAL LEAKAGE (DISLODGED DUCT AS WORST CASE)

CAUSE(S):
PUNCTURE, ABRASION, MATERIAL DEFECT, BROKEN CLAMPS, VIBRATION, MECHANICAL SHOCK

EFFECT(S) ON:
(A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE
(A) "SHORT-CIRCUITED" COOLING AIR FLOW THROUGH FLIGHT DECK AVIONICS LRU'S OR IMU'S.
(B) LOSS OF COOLING AIR FLOW THROUGH FLIGHT DECK AVIONICS LRU'S OR IMU'S.
(C) ABORT DECISION BASED UPON MAGNITUDE OF LEAK.
(D) POSSIBLE LOSS OF CREW/VEHICLE DUE TO FAILURE OF THE AFFECTED AVIONICS AS THE RESULT OF LRU OVERHEATING.

DISPOSITION & RATIONALE:
(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN
CABIN RETURN DUCTS:
THE RETURN DUCTS ARE RIGID EPOXY/ARAMID SECTIONS NOMINALLY ABOUT 18 INCHES LONG AND PREFORMED TO FIT THE CONTOUR OF THE VEHICLE AT THE INSTALLATION SITE. SECTIONS ARE HARD MOUNTED TO STRUCTURE BY A BRACKET/BAND CLAMP ASSEMBLY. A 0.50 INCH STRESS RELIEF GAP IS PROVIDED BETWEEN DUCT SECTIONS. THIS GAP IS BRIDGED BY FLEXIBLE SILICONE/

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FIBERGLASS SLEEVES HELD IN PLACE BY BAND CLAMPS AND GROOVES THAT ARE PREFORMED INTO EACH DUCT SEGMENT. DUCT BRANCHES LEADING TO AVIONICS BOXES ARE PREFORMED INTO THE MAIN DUCT SECTIONS OR MOUNTED TO THE MAIN DUCTS VIA PREFORMED INTERFACE FITTINGS. DUCTS ARE PROTECTED FROM DAMAGE BY CLOSEOUT PANELS.

FLEXIBLE DUCTS OF SILICONE/FIBERGLASS FABRIC OVER STEEL HELICAL SPRING WIRE ARE USED AS REQUIRED AT THE DUCT/AVIONICS BOX INTERFACE. BAND CLAMPS ARE USED TO HOLD FLEXIBLE DUCTS TO LRU AND RIGID DUCT INTERFACES. FLEXIBLE DUCTS ARE PROTECTED FROM DAMAGE BY CLOSEOUT PANELS.

IMU DUCTS:

RIGID DUCTING IS FABRICATED OUT OF ALUMINUM TUBING WITH 0.035 OR 0.049 INCH THICK WALLS. SECTIONS ARE FASTENED TOGETHER WITH CLAMPS AROUND END FLANGES AND HARD MOUNTED TO STRUCTURE BY A BRACKET/BAND CLAMP ASSEMBLY. THE IMU OUTLET MANIFOLD IS WELDED TO THE MAIN ALUMINUM FAN INLET DUCT. FLEXIBLE DUCTS OF SILICONE/FIBERGLASS FABRIC OVER STEEL HELICAL SPRING WIRE ARE USED BETWEEN THE IMU FAN PACKAGE AND THE ALUMINUM DUCTS. DUCTS ARE PROTECTED FROM DAMAGE BY CLOSEOUT PANELS.

A COMPLETELY DISLODGED DUCT IS CONSIDERED TO BE HIGHLY UNLIKELY TO OCCUR DUE TO LOW SYSTEM OPERATING PRESSURE (7 INH2O) AND TIGHT TOLERANCES SPECIFIED BETWEEN THE FLEXIBLE AND RIGID DUCTS.

(B) TEST

FLEXIBLE DUCTS:

ACCEPTANCE TEST - EXTERNAL LEAK TEST AT 0.5 PSIG FOR 5 MINUTES. MAX LEAKAGE 0.005 CFM/INCH DIAMETER/FT LENGTH. PROOF TEST AT 1.0 PSIG FOR 5 MINUTES.

QUALIFICATION TEST - THE SILICONE/FIBERGLASS FLEX DUCTS WERE CERTIFIED BY SIMILARITY AND WERE SHOWN TO WITHSTAND TEMPERATURES FROM -60 F TO 600 F WITHOUT PROBLEMS. NON-NUTRIENT TO FUNGUS DEMONSTRATED BY TEST. SALINITY TOLERANCE DEMONSTRATED BY TEST OF IDENTICAL MATERIAL EXPOSED TO A 20% SALT SOLUTION AT 95 F AND 85% RELATIVE HUMIDITY FOR 50 HOURS WITH NO EFFECT. BURST PRESSURE DEMONSTRATED BY TEST TO BE GREATER THAN 200 PSIG. TRANSIENT AND RANDOM VIBRATION WERE CERTIFIED BY TEST OF THE SIMILAR DUCTS AND CRASH LOADS BY ANALYSIS. QUALIFICATION ANALYSIS AND TEST PER LEVELS SPECIFIED IN MF0004-014.

RIGID DUCTS:

QUALIFICATION TEST - TESTS OF SIMILAR MATERIAL SHOW THAT RIGID EPOXY/ARAMID DUCTS ARE UNAFFECTED BY HUMIDITY AND TEMPERATURE WITHIN THE LIMITS IMPOSED BY THE CABIN ATMOSPHERE. TENSILE STRENGTH (500 KSI) REMAINED UNCHANGED AFTER EXPOSURE TO 100 PHM (PARTS PER HUNDRED MILLION) OZONE AT 70 F FOR 1000 HOURS. TOLERANCE TO SALINITY WAS DEMONSTRATED BY ANALYSIS BASED ON TESTS OF SIMILAR MATERIAL IN SALT WATER FOR 125 DAYS. TRANSIENT VIBRATION, RANDOM VIBRATION, AND CRASH LOADS WERE CERTIFIED BY ANALYSIS. QUALIFICATION ANALYSIS AND TEST PER LEVELS SPECIFIED IN MF0004-014.

IN-VEHICLE TESTING - CABIN FAN DELTA-P IS MONITORED CONTINUOUSLY WHEN THE VEHICLE IS POWERED UP AND SERVES AS AN INDICATION OF LEAKAGE. DUCT INSTALLATION IS INSPECTED FOR DAMAGE PRIOR TO INSTALLATION OF CLOSEOUT

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PANELS.

IMU FAN DELTA-P IS MONITORED CONTINUOUSLY WHEN IMU'S ARE POWERED UP.

OMRSD - CABIN FAN DELTA-P IS MONITORED DURING EVERY TURNAROUND AND SERVES AS AN INDICATION OF SYSTEM PERFORMANCE/EXTERNAL LEAKAGE.

FLEXIBLE AND HARD DUCTS ARE BEING COMPLETELY INSPECTED PRIOR TO FIRST REFLIGHT OF EACH ORBITER AND ARE ALSO INSPECTED AS AVAILABLE IN CONJUNCTION WITH REMOVAL OF PANELS/LRU'S. DUCTS ARE ALSO INSPECTED DURING PERIODIC ZONAL INSPECTIONS.

IMU FAN DELTA-P IS MONITORED CONTINUOUSLY WHEN IMU'S ARE POWERED UP; VERIFIED EVERY TURNAROUND. A DECREASE IN FAN DELTA-P WOULD BE AN INDICATION OF EXTERNAL LEAKAGE.

(C) INSPECTION

CABIN DUCTS:

RECEIVING INSPECTION

CERTIFICATION OF MATERIALS AND PROCESSES IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

INSPECTION VERIFIES THE FOLLOWING: PROCESS REQUIREMENTS RELATIVE TO MATERIALS PREPARATION, FABRICATION OF DUCT SECTIONS (INCLUDING DUCT LENGTH AND WALL THICKNESS) AND CURE CYCLES IN ACCORDANCE WITH REQUIREMENTS, INSTALLATION OF CURED SECTIONS INTO THE DUCT SYSTEM (BONDING, SPLICING, SEAL COATING, INSTALLATION OF CLAMPS, FASTENERS, TAPE AND INSULATION) IN ACCORDANCE WITH DRAWING AND SPECIFICATION REQUIREMENTS.

TESTING

THE ATP, WHICH INCLUDES LEAK AND PROOF TESTING, EXAMINATION FOR WORKMANSHIP, FINISH AND DIMENSIONAL FEATURES IS VERIFIED BY INSPECTION.

PACKAGING AND HANDLING

PARTS PROTECTION AND HANDLING REQUIREMENTS ARE VERIFIED BY INSPECTION.

IMU DUCTS:

RECEIVING INSPECTION

MATERIAL AND PROCESS CERTIFICATION ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CONTAMINATION CONTROL AND CORROSION PROTECTION PER MA0608-301 ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

MANUFACTURING, INSTALLATION AND ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION. STANDARD DETAIL, DIMENSIONING AND TOLERANCING ARE VERIFIED BY INSPECTION. INSPECTION VERIFIED TUBING FABRICATION PER MA0102-306.

CRITICAL PROCESSES

WELDING PER MA0107-303 IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

PENETRANT INSPECTION IS VERIFIED BY INSPECTION.

TESTING

THE ATP, WHICH INCLUDES LEAK AND PROOF TESTING, EXAMINATION FOR WORKMAN-

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SHIP, FINISH AND DIMENSIONAL FEATURES IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PARTS PROTECTION AND HANDLING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

THERE IS NO FAILURE HISTORY OF THE RIGID DUCT. THE FLEXIBLE DUCTS HAVE DEVELOPED MINOR LEAKS THAT HAVE BEEN CAUSED BY ABRASION AND PUNCTURE DUE TO INTERFERING WITH THE SURROUNDING STRUCTURE. NONE OF THE LEAKAGE TO DATE HAS RESULTED IN SIGNIFICANT AIR FLOW REDUCTION TO CAUSE OVERHEATING AND SUBSEQUENT FAILURE OF AVIONICS EQUIPMENT. A REDESIGN IS IN PROGRESS WHICH WILL REPLACE THE STEEL SPRING IN THE DUCT WITH A NYLON SPRING AND THE FIBERGLASS SILICON SHEATH WITH ARAMID/SILICON FABRIC. CAR AD187-010, DATED 7/15/87, WAS OPENED AGAINST DUCTS REMOVED DURING COMPLETE INSPECTION OF OV-103 DUCTS. IT REMAINS OPEN PENDING REDESIGN.

(E) OPERATIONAL USE

CABIN RETURN DUCTS:

1. CREW ACTION
 - A. CABIN FAN PERFORMANCE TROUBLESHOOTING.
 - B. AVIONICS LRU FAILURE TROUBLESHOOTING.
2. TRAINING
CURRENT ECLSS TRAINING COVERS THE EFFECT OF CABIN FAN PERFORMANCE DEGRADATION.
3. OPERATIONAL CONSIDERATIONS
 - A. LRU PERFORMANCE DEGRADATION FROM SPEC PERFORMANCE IS NOT WELL KNOWN.
 - B. REAL TIME DATA SYSTEM ALLOWS FOR GROUND MONITORING.
 - C. IFM REPAIR WOULD BE CONSIDERED DEPENDING ON LOCATION OF LEAKAGE.

IMU DUCTS:

1. CREW ACTION
FAN PERFORMANCE DEGRADATION TROUBLESHOOTING.
2. TRAINING
CURRENT ECLSS TRAINING COVERS THE FAN PERFORMANCE DEGRADATION EFFECT OF THIS FAILURE.
3. OPERATIONAL CONSIDERATIONS
 - A. REAL TIME DATA SYSTEM ALLOWS FOR GROUND MONITORING.
 - B. ALTERNATE POWER CYCLING OF EACH OF THE THREE IMU'S IS POSSIBLE.
 - C. IFM REPAIR WOULD BE CONSIDERED DEPENDING ON ACCESSIBILITY OF DUCT LEAK.