

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE****NUMBER: 03-1-0408 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 08/07/00**PART DATA**


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	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	:17" DISC VALVE ASSY, ORB LO2 BOEING	MC284-0389-1561
LRU	: 17" DISC VALVE ASSY, ET LO2 BOEING	MC284-0389-0702

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

DISCONNECT, LO2 FEED (WITH LATCH) 17 INCH, ORBITER &amp; ET HALF.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY PARKER-HANNIFIN. BOEING IS A CERTIFIED ALTERNATE PRODUCTION AGENCY.

**REFERENCE DESIGNATORS:** PD1**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

ET/ORBITER FEED LINE DISCONNECT PROVIDES LO2 PROPELLANT TO THE MPS AND A MEANS OF LOADING AND DETANKING THE ET. EACH DISCONNECT HALF CONTAINS A PNEUMATICALLY ACTUATED FLAPPER CLOSURE DEVICE WHICH REMAINS IN ITS LAST ACTUATED POSITION (BISTABLE). THE VALVES ARE CLOSED AFTER MECO TO PREVENT PROPULSIVE VENTING LEADING TO ET/ORBITER RECONTACT, TILE/DOOR DAMAGE DUE TO EXPOSURE TO PROPELLANTS, LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION, AND SYSTEM CONTAMINATION DURING ENTRY. DURING UMBILICAL SEPARATION, THE VALVE SYSTEM IS DESIGNED TO MECHANICALLY CLOSE BOTH THE ORBITER AND ET DISCONNECT FLAPPERS IF UNABLE TO CLOSE THEM PNEUMATICALLY (POST MECO). REDUNDANT OPEN AND CLOSE (TWO EACH) VALVE POSITION SWITCHES ARE LOCATED ON THE ORBITER HALF OF THE DISCONNECT. THE FLAPPER DRIVE MECHANISM IS DESIGNED TO ALLOW RELIEF OF PROPELLANTS TRAPPED BETWEEN THE FLAPPERS AFTER DISCONNECT CLOSURE.

A PNEUMATICALLY ACTUATED LATCH MECHANISM IS PROVIDED TO PREVENT THE VALVE FLAPPERS FROM CLOSING DURING FLOW CONDITIONS. THE LATCH IS BISTABLE AND IS CONTROLLED BY A SEPARATE PNEUMATIC ACTUATOR ASSEMBLY WITH REDUNDANT

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LOCK AND UNLOCK (TWO EACH) POSITION SWITCHES. LATCH MECHANISM INCORPORATES TOGGLE PIVOT WHICH ALLOWS FLAPPER CLOSURE DURING BACK UP MECHANICAL SEPARATION WITH LATCH IN LOCKED POSITION. SEE LATCH FMEA/CIL 03-1-0454 FOR ADDITIONAL INFORMATION.

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: 17" LO2 FEEDLINE DISC ORB/ET (PD1)**

**ITEM NAME: 17" LO2 FEEDLINE DISC ORB/ET (PD1)**

**CRITICALITY OF THIS**

**FAILURE MODE: 1R2**

**FAILURE MODE:**

LOSS OF POSITION INDICATION DURING ET SEPARATION (FLAPPER IS CLOSED).

**MISSION PHASE: LO LIFT-OFF**

<b>VEHICLE/PAYLOAD/KIT EFFECTIVITY:</b>	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

**CAUSE:**

POSITION SWITCH ASSEMBLY FAILURE, ELECTRICAL POWER LOSS

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

**REDUNDANCY SCREEN**

- A) PASS
- B) FAIL
- C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

FAILS B SCREEN BECAUSE SWITCH FAILURE IS INDISTINGUISHABLE FROM DISCONNECT FAILS TO CLOSE AT MECO.

C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

PIECE PART STRUCTURAL FAILURE OF CAM FAILS TO ACTUATE BOTH CLOSED POSITION SWITCHES. THE DISCONNECT FLAPPER WILL CLOSE, HOWEVER, THE VEHICLE SOFTWARE WILL INHIBIT ET STRUCTURAL SEPARATION SINCE BOTH DISCONNECT CLOSED SWITCHES WILL INDICATE "OFF."

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**(B) INTERFACING SUBSYSTEM(S):**

SAME AS A.

**(C) MISSION:**

FOR NOMINAL, ATO, AND AOA ET SEPARATION WILL BE DELAYED 6 MINUTES BECAUSE THE FLAPPER CANNOT BE VERIFIED CLOSED. THIS DELAYED SEPARATION PROCEDURE IS PERFORMED TO PREVENT ORBITER/ET RECONTACT DUE TO PROPULSIVE VENTING AT SEPARATION IF THE FLAPPER HAS FAILED TO CLOSE.

NO EFFECT FOR RTLS, TAL, OR MISSIONS WHERE THE OMS BURN CANNOT BE DELAYED, BECAUSE ET SEPARATION IS NOT DELAYED.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

1R/2 2 SUCCESS PATHS - TIME FRAME: DELAYED ET SEPARATION

- 1) SWITCH MECHANISM FAILURE CAUSES BOTH POSITION INDICATORS FAIL TO INDICATE CLOSED.
- 2) LH2 OR LO2 ET RELIEF VALVE FAILS TO OPEN

POSSIBLE RUPTURE OF EXTERNAL TANK. POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

A PNEUMATIC ACTUATOR MOUNTED ON THE ORBITER HALF OF THE DISCONNECT DRIVES THE ET FLAPPER THROUGH A ROLLER/CLEVIS LINKAGE. THIS ACTION IN TURN DRIVES A SECOND ROLLER/CLEVIS LINKAGE WHICH OPERATES THE ORBITER FLAPPER AND THE POSITION INDICATOR ASSEMBLY. THE POSITION INDICATOR SWITCH ASSEMBLY IS MOUNTED ON THE ORBITER HALF OF THE DISCONNECT AND IS ACTUATED BY MOTION OF THE ORBITER FLAPPER DRIVESHAFT.

THE SWITCH ASSEMBLY CONSISTS OF FOUR SWITCHES (TWO FOR CLOSE, TWO FOR OPEN) FOR REDUNDANCY. EACH SWITCH HAS AN INDEPENDENT ELECTRICAL CIRCUIT. THEY ARE MECHANICALLY ACTIVATED MICROSWITCHES.

THE POSITION INDICATOR HOUSING ASSEMBLY IS OF 6061-T651 AL ALLOY, ANODIZED. THE DRIVESHAFT AND LINK ARE OF 304 CRES, PASSIVATED. THE SPRING (PROVIDING FORCE IN COMPRESSION TO HOLD CAM AGAINST CAM TRACK) IS OF 302 CRES, PASSIVATED. THE CAM WHICH PROVIDES FORCE TO ACTUATE SWITCH ASSEMBLIES IS OF VESPEL SP-21, AND THE CAM TRACK IS OF 6061-T651 AL ALLOY ANODIZED. MATING SURFACE FINISHES ARE 16 MICROINCHES.

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**(B) TEST:**

ATP (ACTUATOR)

PROOF: AMBIENT, 1275 PSIG

OPERATIONAL (TWO CYCLES): AMBIENT; 400, 740, 780 PSIG

RESPONSE TIME (OPENING/CLOSING): ROOM AMBIENT/-300 DEG F RESPONSE TIME  
AT 400, 700 AND 780 PSIG

LEAKAGE: EXTERNAL AND INTERNAL, AMBIENT AND CRYO

ATP - ET/ORBITER MATED DISCONNECT ASSEMBLY

FLAPPER ANGLE: ET 4.5 +/- 0.25 DEG, ORB 3.0 +/- 0.25 DEG

TIP LOAD: ET 55 LBF MINIMUM, ORB 40 LBF MINIMUM

POSITION SWITCH VERIFICATION: LATCH IN LOCKED POSITION. ROTATION FROM  
FLAPPER POSITION OF REST ON DOWNSTRIKE SURFACE TO FLAPPER POSITION  
WHERE OPEN INDICATOR LIGHT TURNS ON MUST BE 4 DEG, MINIMUM.

PROOF: AMBIENT, 1275 PSIG, ACTUATOR  
286 PSIG FOR ORBITER CLOSURE DEVICE  
58 PSIG FOR ET CLOSURE DEVICE

OPERATIONAL CYCLE: CRYO, -300 DEG F, ACTUATOR PRESSURE 740 PSIG FOR 8  
CYCLES AND 450 PSIG FOR 5 CYCLES  
AMBIENT, HE AT 400 PSIG (1 CYCLE) AND 740 PSIG (5  
CYCLES)

CLEANLINESS VERIFICATION: MOISTURE FREE AND CLEANED TO LEVEL 400A OF MA  
0110-301

LEAKAGE: EXTERNAL

VALVE: LN2/AMBIENT TEMPS: 50 SCIM OF GHE AT 10 PSIG, 50 SCIM  
OF GHE AT 50 PSIG; LATCH SHAFT SEAL, 80 SCIM OF GHE;  
150 SCIM OF GN2 AT 185 PSIG; LATCH SHAFT SEAL, 80 SCIM  
OF GN2

VALVE ACTUATOR:

CRYO (BODY TEMP AT -300 DEG F, ACTUATOR AT -200 TO 0  
DEG F)/AMBIENT TEMPS; 100 SCIM OF GHE AT 740 PSIG

INTERNAL

VALVE: AMBIENT TEMPS: 1000 TO 2000 SCIM OF GHE AT 1 TO 15  
PSIG; 2500 SCIM OF GN2 AT 200 PSIG LN2 TEMPS: 2500 SCIM  
OF GHE AT 60 PSIG; 2500 SCIM OF GN2 AT 200 PSIG

VALVE ACTUATOR:

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CRYO (BODY TEMP AT -300 DEG F, ACTUATOR AT -200 TO 0 DEG F)/AMBIENT TEMPS: 100 SCIM OF GHE AT 740 PSIG

RELIEF OPERATION: -300 DEG F, CRACKING/RESEAT PRESSURE, 0.1-5 PSID (ET ONLY)

ELECTRICAL CHARACTERISTICS (INSULATION RESISTANCE AND VOLTAGE DROP), AND DIELECTRIC STRENGTH

FLOW LINER - ROUNDNESS VERIFICATION (FREE END EIGHT POINTS MEASUREMENT)

CERTIFICATION

COMPONENT QUALIFICATION (INCLUDES TESTING FROM PREVIOUS CONFIGURATION WITHOUT LATCH)

SALT FOG

VIBRATION - THREE AXES:

SINUSOIDAL: 5 TO 35 HZ AT 0.25 G, ZERO TO PEAK

RANDOM: 20 TO 2,000 HZ 5.7 G RMS FOR X-AXIS, 5.2 G RMS FOR Y AND Z-AXIS, NO FLOW (LN2), FLAPPERS OPEN, LATCH ENGAGED

THE DISCONNECT IS CHILLED WITH LN2 AND STABILIZED AT -300 DEG F. 10 PSIG DISCONNECT, 740 PSIG ACTUATOR. THESE CONDITIONS ARE MAINTAINED THROUGHOUT SINUSOIDAL AND RANDOM VIBRATION. ACTUATOR VENTED DURING LAST TWO MINUTES OF VIBRATION.

THERMAL CYCLE: -400 TO 150 DEG F, 3 CYCLES

OPERATING LIFE: AMBIENT, 740 PSIG HE FOR A TOTAL OF 2,400 CYCLES FOR ORBITER AND 100 CYCLES FOR ET. THE RELIEF MECHANISM WAS CYCLED DURING ET VALVE CYCLING.

CRYO, 740 PSIG HE, -400 DEG F FOR A TOTAL OF 1000 CYCLES FOR ORBITER AND 50 CYCLES FOR THE ET. THE RELIEF MECHANISM WAS CYCLED DURING ET VALVE CYCLING.

ELECTRICAL CHARACTERISTICS (INSULATION RESISTANCE AND VOLTAGE DROP)

LEAKAGE: EXTERNAL AND INTERNAL, AMBIENT AND CRYO

ENGAGE - DISENGAGE: ENGAGE FORCE = 1000 LBF MAX,  
DISENGAGE FORCE = 6000 LBF MAX

BURST TEST:

PNEUMATIC ACTUATOR, 1700 PSIG HYDROSTATIC PRESSURE FOR 2 MINUTES

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TYPE I AND TYPE II MATED (OPEN POSITION) 450 PSIG HYDROSTATIC PRESSURE FOR 2 MINUTES

TYPE I AND TYPE II DEMATED (CLOSED POSITION) 330 PSID TO TYPE I, 68 PSID TO TYPE II FOR 2 MINUTES

UMBILICAL SEPARATION TEST: (WITHOUT LATCH)

THE DISCONNECT WAS INSTALLED IN THE UMBILICAL ASSEMBLY DURING THE SEPARATION TEST PROGRAM. THE UMBILICAL ASSEMBLY WAS SUBJECTED TO RANDOM VIBRATION TESTS (4.4 HOURS PER AXIS) WHILE FILLED WITH LN2. THE DISCONNECT WAS ALSO SUBJECTED TO UMBILICAL RETRACT TESTS AT BOTH NOMINAL CONDITIONS AND SIMULATED HYDRAULIC RETRACT ACTUATOR FAILURES.

UMBILICAL SEPARATION TEST: (WITH LATCH)

FLAPPER PNEUMATICS/LATCH PNEUMATICS/PYROS/RETRACTOR HYDRAULICS

- (1) PNEUMATIC CLOSURE (NORMAL) - 4 CYCLES
- (2) MECHANICAL CLOSURE (BACKUP) - 5 CYCLES

BOTH PERFORMED AT AMBIENT, LN2 AND LH2 CONDITIONS.

TERMINAL DRAIN: (SATURATED LO2) (65% AND 109%) LATCH ENGAGED AND NOT ENGAGED.

FLOW LINER WATER FLOW TESTS:

DESIGN FLOW TO 19,600 GPM  
ALLOWABLE DELTA P IS 10 PSID AT THE LINER

TO DETERMINE THE STABILITY OF THE FLOW LINER. THE FLOW TUBE HAD NO PERMANENT DAMAGE AFTER BEING SUBJECTED TO WATER FLOWS UP TO 20,000 GPM (TEST TIME OF 2 MINUTES / 6 RUNS MINIMUM). AFTER VERIFYING PERFORMANCE AT 20,000 GPM, THE UNIT WAS SUBJECTED TO 22,700 GPM TO VERIFY DESIGN MARGIN (NO PERMANENT DAMAGE).

FLAPPER ANGLE STABILITY MARGIN WATER FLOW TESTS:

FOURTEEN (14) EXPLORATORY TEST SERIES (FLOW 4,000 TO 20,800 GPM) E.T. FLAPPER SETTING VARYING FROM 1.6 TO 5.8 DEG. ORB. FLAPPER SETTING VARYING FROM 0.9 TO 5.4 DEG.

CERTIFICATION TEST RUN AT WORST CASE PRODUCTION SETTING (FLOW RANGE TO 109% POWER LEVEL).

PROOF TEST SERIES - MAXIMUM FLOW 22,700 GPM, AT ANGLES BELOW MINIMUM FLIGHT SETTINGS

PRODUCTION ANGLE SETTINGS  
E.T. 4.5 +/- 0.25 DEG

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ORB. 3.0 +/- 0.25 DEG

FLAPPER TIP LOAD MARGIN WATER FLOW TEST:

EIGHT (8) EXPLORATORY TEST SERIES (FLOW RANGE TO 109% POWER LEVEL)

FLOW 4,000 TO 20,600 GPM

ORBITER: 3.0 +/- 0.1 DEG FOR SEVEN SERIES, 4.1 +/- 0.1 FOR ONE SERIES TIP LOAD  
RANGE: 20 TO 62 LBF

ET: 3.95 +/- 0.1 DEG  
TIP LOAD RANGE: 23 TO 61 LBF

RECOMMENDED TIP LOAD:

ORBITER: 40 LBF MINIMUM  
ET: 55 LBF MINIMUM

LATCH WATER FLOW TESTS:

TWENTY-FOUR (24) EXPLORATORY TEST SERIES (FLOW 4,000 TO 22,100 GPM)

CERTIFICATION TEST RUN AT MINIMUM PRODUCTION SETTING (FLOW RANGE TO 109%  
POWER LEVEL).

TWO TEST SERIES IN FILL DIRECTION (FLOW 4,000 TO 6,400 GPM), LATCH PNEUMATIC  
PRESSURE VENTED (BISTABILITY)

PROOF TEST - 23,200 GPM

LATCH CRYO FLOW TESTS:

SIXTEEN (16) TESTS WITH LN2/LO2 (FLOWS VARY FROM ONE ENGINE AT 65% TO THREE  
AT 109%):

DISCONNECT FLAPPER STABILITY/LOADS

CAVITATION

FRICION PRESSURE LOSS

ENGINE CUTOFF SENSOR RESPONSE

STEADY STATE TEST: LN2 (65% AND 109% OF RATED POWER LEVEL),  
LATCH ENGAGED. LO2 (100%, 104% AND 109% OF RATED POWER LEVEL),  
LATCH ENGAGED AND NOT ENGAGED.

TERMINAL DRAIN: (SATURATED LO2) (65% AND 109%) LATCH ENGAGED AND NOT ENGAGED.

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.



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**(C) INSPECTION:**

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION. ALL MACHINED ITEMS ARE DIMENSIONALLY INSPECTED AND VERIFIED (MIL-STD-105). CHEMICAL/MECHANICAL PROPERTIES AND RECORDS OF RECEIVED MATERIALS ARE RETAINED FOR VERIFICATION. BODY FORGING IS ULTRASONICALLY AND DYE PENETRANT INSPECTED.

CONTAMINATION CONTROL

CLEANLINESS LEVEL TO 400A VIA FREON FLUSH AND SAMPLE VERIFIED. ALL SEAL GROOVES ARE INSPECTED FOR CLEANLINESS AND EVIDENCE OF DAMAGE.

ASSEMBLY/INSTALLATION

THREADED INSERTS AND CRITICAL DIMENSIONS VERIFIED BY INSPECTION. SEALING SURFACES ARE VISUALLY INSPECTED FOR DEFECTS. REPAIRED AND REWORKED ITEMS ARE DIMENSIONALLY CHECKED. LOG OF CLEAN ROOM VERIFIED. ALL ENGINEERING-DEFINED FEATURES AND SURFACE FINISHES AND TORQUE REQUIREMENTS ARE COMPLETELY INSPECTED AND VERIFIED.

THE PRIMARY INTERFACE SEAL IS CHECKED FOR ID, OD AND ROUNDNESS. ALL DIMENSIONS DEFINED IN DRAWING ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES

HEAT TREATMENT AND PART PASSIVATION ARE VERIFIED BY INSPECTION.

NON-DESTRUCTIVE EVALUATION

PARTS ARE RADIOGRAPHICALLY AND DYE PENETRANT INSPECTED AS IMPOSED BY ENGINEERING IN THE DRAWING REQUIREMENTS.

TESTING

ATP AND TEST MEASUREMENT EQUIPMENT CALIBRATION VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

TWO FAILURES OCCURRED DURING ATP WHEREBY THE POSITION INDICATOR SWITCHES DID NOT RESPOND CORRECTLY (REFERENCE CAR'S A6420, A6421). THE ACTUATOR LINK WAS REDESIGNED AND THE ASSEMBLY INSTRUCTIONS WERE ALSO REVISED TO SHOW VERIFICATION THAT BOTH SWITCHES WERE FUNCTIONING PROPERLY.

THREE INCIDENTS OF SWITCH ADJUSTMENT PROBLEMS OCCURRED (CAR'S AB3630, AB4043, AB4493). THE ASSEMBLY PROCEDURE WAS REVISED TO ASSURE SPECIFIC OVERTRAVEL AND VERIFICATION OF CORRECT OPERATION BY A CRYOGENIC SUBASSEMBLY TEST.

AN INTERMITTENT OPERATING UNIT WAS REPORTED FROM NSTL (REFERENCE CAR AB6951). THE ASSEMBLY WAS NOT THE LATEST REVISION AND WAS REPLACED.

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A ONE TIME ANOMALY, WHEREBY A MICROSWITCH FAILED TO PICK UP A CLOSED INDICATION, OCCURRED ON OV103 AT KSC (REFERENCE CAR AC9680). THE FAILURE COULD NOT BE REPEATED.

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

**(E) OPERATIONAL USE:**

FOR NOMINAL, ATO AND AOA MISSIONS, ET SEPARATION WILL BE MANUALLY PERFORMED 6 MINUTES AFTER MECO. THE MPS DUMP IS PERFORMED DURING THIS WAIT PERIOD. DUE TO THE TIME CRITICAL NATURE OF RTLS AND TAL, SEPARATION IS PERFORMED IMMEDIATELY.

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**- APPROVALS -**

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S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: KOUROSH ANVARI	: /S/ FOR - LUIS RODRIGUEZ
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	: /S/ ERICH BASS