Description of document:	National Aeronautics and Space Administration (NASA) Space Shuttle STS-4 Final Flight Evaluation Report Volume I 1982
Requested date:	01-July-2021
Release date:	21-September-2021
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National Aeronautics and Space Administration

Headquarters
Office of Communications
Washington, DC 20546-0001

September 21, 2021

Reply to Attn of: FOIA Office

Via Email

REF: FOIA Case No. 21-HQ-F-00582

This is our final determination of your Freedom of Information Act (FOIA) request, dated July 1, 2021, and received by the National Aeronautics and Space Administration ((NASA) Headquarters (HQ) FOIA Office on July 7, 2021. Your request was assigned FOIA Case Number 21-HQ-F-00582 and sought:

> "A copy of the final report or reports on the Failure of the SRB (Solid Rocket Booster) recovery on the STS-4 space shuttle mission."

In response to your request, we conducted searches of NASA's Office(s) of Johnson Space Center (JSC) Retired Space Shuttle Program, Marshall Space Flight Center (MSFC) Heavy Lift and Propulsion Research and Development, and MSFC System Launch System (SLS) Office (Boosters Program) using the search terms STS-4 Solid Rocket Booster Recovery Report. Those searches did not locate any final report on the recovery system failure and/or SRB recovery in particular. However, one of the searches conducted by the MSFC SLS Office located one document titled "STS-4 Final Flight Evaluation Report" that may be of interest to you. We determined that all 192 pages are appropriate for release without excision and copies are enclosed.

Appeal Rights

If you believe this to be an adverse determination, you have the right to appeal my action on your FOIA request. Your appeal must be received within 90 calendar days of the date of this response. Your appeal must be in writing and addressed to:

Administrator
ATTN: FOIA Appeals
NASA Headquarters
Executive Secretariat
MS 9R17
Washington, DC 20546

Both the envelope and letter of appeal should be clearly marked "Appeal under the Freedom of Information Act." You must also include copies of your initial request, this correspondence, and any other correspondence with the FOIA office. In order to expedite the appellate process and ensure full consideration of your appeal, your appeal should also contain a brief statement of the reasons you believe this initial determination should be reversed. Additional information on submitting an appeal is set forth in the NASA FOIA regulations at 14 C.F.R. § 1206.700.

Assistance and Dispute Resolution Services

If you have any questions, please feel free to contact me at Mireya.P.Nyirenda@nasa.gov. For further assistance and to discuss any aspect of your request, you may contact:

Stephanie Fox
Chief FOIA Public Liaison
Freedom of Information Act Office
NASA Headquarters
300 E Street, S.W., 5P32
Washington D.C. 20546
Phone: 202-358-1553
Email: Stephanie.K.Fox@nasa.gov

Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services it offers. The contact information for OGIS is as follows:

Office of Government Information Services
National Archives and Records Administration
8601 Adelphi Road-OGIS
College Park, Maryland 20740-6001
Email: ogis@nara.gov
Telephone: (202) 741-5770
Toll-free: 1-877-684-6448
Fax: (202) 741-5769

Important: Please note that contacting any agency official including the undersigned, NASA's Chief FOIA Public Liaison, and/or OGIS is not an alternative to filing an administrative appeal and does not stop the 90 day appeal clock.

Sincerely,

Mia Nyirenda
Digitally signed by Mireya Nyirenda
Date: 2021.09.21 16:56:51 -04'00'

MIREYA P. NYIRENDA
FOIA Public Liaison Officer

National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Space Shuttle
STS-4
Final Flight Evaluation Report

Volume I

Solid Rocket Boosters

External Tank

Shuttle Main Engines

Range Safety System

September 22 ,1982

MSFC - Form 454 (Rev. October 1976)

GEORGE C. MARSHALL SPACE FLIGHT CENTER

SPACE SHUTTLE
STS-4 FINAL FLIGHT EVALUATION REPORT

PREPARED BY
SHUTTLE PROJECTS FLIGHT EVALUATION WORKING GROUP
MARSHALL SPACE FLIGHT CENTER

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ACKNOWLEDGEMENT

This report is published by the Marshall Space Flight Center (MSFC) Flight Evaluation Working Group (FEWG) with contributions from the Kennedy Space Center, the Johnson Space Center and several NASA contractors. The report was coordinated, compiled and edited by the FEWG Staff at Rockwell International/Space Operations/Integration and Satellite Systems Division/Huntsville Operations. Significant contributions to the evaluation were made by:

George C. Marshall Space Flight Center
- Science and Engineering
  - Associate Director for Engineering
  - Electronics & Control Laboratory
  - Systems Dynamics Laboratory
  - Data Systems Laboratory
  - Systems Analysis and Integration Laboratory
  - Structures and Propulsion Laboratory
- Administration and Program Support (Computer Services Office)
- Program/Project Offices (Shuttle Projects Office)

John F. Kennedy Space Center (Launch Operations)

Lyndon B. Johnson Space Center (Main Propulsion System)

Bendix Guidance Systems Division (SRB Subsystems)

Chrysler Corporation/Slidell (SRB Loads)

Lockheed/Huntsville (Base Heating)

Martin Marietta Corporation
- Denver (SRB Decelerator Subsystem)
- Michoud Assembly Facility (ET)

Remtech (Base & Aeroheating)

Rockwell International Corporation
- Rocketdyne Division (SSME)
- Space Operations/Integration & Satellite Systems Division
  - (Integrated Systems - Main Propulsion System)

Thiokol Chemical Corporation/Wasatch Division (SRM)

USBI/Huntsville (SRB Systems & ET Range Safety System)

VOLUME I

TABLE OF CONTENTS

1.0 FLIGHT SUMMARY - This section provides a description of the STS-4 flight and a summary of the evaluation results which are detailed in the remainder of the report. MSFC STS-4 results are reported in two volumes. Volume 1 covers the evaluation results for the Solid Rocket Boosters (SRBs), the External Tank (ET), the Space Shuttle Main Engines (SSMEs) and the Range Safety System (RSS). Volume 2 reports the evaluation of MSFC responsible systems tasks: the Main Propulsion System (MPS), the Shuttle Ascent Base Heating Environment, ET Separation, Entry and Breakup and Ignition Overpressure.

1.1 FLIGHT DESCRIPTION - The fourth launch of the Space Shuttle Orbiter Columbia (STS-4) occurred on June 27, 1982 at 11 A.M. EDT. The final countdown was normal. The SSME and SRM ignitions occurred as expected. Ascent performance during the roll maneuver, the max Q throttle back and the 3G throttling was as expected. SRB separation occurred approximately 3 seconds later than expected due to a longer SRM burn time than predicted.

ET separation and reentry occurred as planned with the ET tumble system operating properly. ET debris fell within the predicted footprint.

1.2 FLIGHT RESULTS - All STS-4 mission critical functions associated with the MSFC elements (SRBs, ET and SSMEs) were performed satisfactorily. The following paragraphs summarize the evaluation results for each MSFC element.

1.2.1 SRB SUMMARY - SRM propulsion performance parameters were within specification limits and showed good reproducibility with previous flights. SRB thrust differentials also were within specification.

All Thrust Vector Control (TVC) prelaunch redlines were met with ample margin. Analyses verified that all TVC system parameters indicated nominal operation during flight.

The SRB support post loads data at liftoff showed footpad compression and holdown bolt tension to be within design limits.

SRB base moment calculations based upon MLP support strain data indicated a moment 94% of design during SSME buildup.

No data were available for strut loads analysis. The SRM motor case loads (axial force) show good agreement with STS-3.

The Electrical and Instrumentation (E&I) operational system evaluation indicates, within the resolution of available data, that all ascent functions were performed nominally. Based on available data, all indications are that the E&I separation functions performed nominally. The bulk of the SRB DFI data was lost resulting in no data after separation.

No data are available on SRB reentry aerodynamics. Available data from Orbiter recorders indicated no vibroacoustic exceedances during ascent. Temperature limits experienced by primary structures and subsystem components have not been verified due to a lack of data.

The loss of DFI data prevents analysis of BSM pressure performance curves. Available photographic data and visual inspection reviews indicate no debris from BSMs during separation.

Reentry trajectory characteristics of each SRB were similar to the nominal until end of drogue parachute phase. A separate report will be issued on the failures related to both SRBs.

1.2.2 ET SUMMARY - Prelaunch and ascent thermal environments were nominal.

ET vibroacoustic levels were near or below predicted values for all measurement locations.

Flight dynamic parameters revealed no indication of LO2 slosh activity.

ET compartment venting predictions for STS-4 were as expected.

There were no ET design load exceedances for STS-4. All ET loads & strains were equal to or less than expected.

1.2.3 SSME SUMMARY- All prelaunch purge operations (pretanking purges, intertank purges and GN2 purges) were executed successfully with contamination concentrations remaining well within requirements. The launch support GSE provided adequate control capability and satisfactory operation for launch preparation.

All three SSMEs ignited properly. Buildups and shutdowns of all engines as well as mainstage performances were within specifications. The SSME controllers provided nominal control of the engines throughout powered flight. Oscillations of the MCC chamber pressure measurement occurred on ME-2 during throttling. These oscillations had been observed on previous tests with this controller and have caused no detrimental effects.

POGO system operation was normal. Engine gimbal operations were normal in response to Orbiter commands.

Hydraulic system pressure and temperature were within allowable limits throughout flight. Helium interface requirements were met on all three engines. SSME thermal data showed no problems which could impact future flights. Engine dynamic data were generally comparable to previous tests and indicate no problems.

All on-orbit activities associated with the SSME were accomplished successfully. There was no damage to the SSMEs or nozzles during Orbiter reentry and landing.

During postflight inspections, a high torque was noted on the HPFTP of ME-3. Subsequent teardown of the pump revealed a piece of second stage impeller missing. The pump has been replaced for STS-5.

1.2.4 RANGE SAFETY SYSTEM SUMMARY - Analysis indicates that the performance of the Range Safety System hardware for both the SRBs and the ET was as expected.

1.3 VERIFICATION - Table 1.3-1 lists Level II and III requirements applicable to MSFC to be verified by the appropriate Shuttle Project Office and the degree to which these requirements were met for the Flight Readiness Firing, STS-1, STS-2, STS-3 and STS-4.

The loss of SRB data has delayed the planned completion of several requirements. In all areas in which data were available, requirements were at least partially satisfied. In some areas all Flight Test Requirements have been completed. There were no problems or anomalies associated with the STS-4 flight which are considered a constraint for STS-5.

TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.1 SHUTTLE SYSTEM DEFINITION											
3.1.3 SHUTTLE SYSTEM WEIGHTS & PERFORMANCE CONTROL - VERIFY ELEMENT CONTROL WEIGHTS DEFINED IN APPENDIX 10.12			X	X	X	S	S	S	S	S	
41VV011 ESTABLISH CLOSE TOLERANCE ON LIQUID OXYGEN RESIDUALS	5.3.2				X	N/A	S	S	S	S	
41VV012 ESTABLISH CLOSE TOLERANCE ON LIQUID HYDROGEN RESIDUALS	5.3.2				X	N/A	S	S	S	S	
41VV019 DEVELOP PROCEDURES TO FULFILL LO2 LOADING ACCURACY	5.3.1				X	S	P	S	S	S	
41VV019A DEVELOP PROCEDURES TO FULFILL LH2 LOADING ACCURACY	5.3.1				X	S	S	S	S	S	
41VV023 VERIFY CAPABILITY TO PREDICT MPS FLIGHT PERFORMANCE	5.3.2,				X	S	P	P	P	P	
	5.4.1,				X	S	P	P	P	P	
	5.4.2,				X	S	P	P	P	P	
	5.4.3				X	S	P	P	P	P	
MC-1 VERIFY SHUTTLE VEHICLE ASCENT PERFORMANCE IN FLIGHT	2.2.0,			X		N/A	S	S	S	S	
	5.3.1,				X	N/A	S	S	S	S	
	5.3.2				X	N/A	S	S	S	S	
SRB CEI, CP013M00000B											
MASS PROPERTIES, PARA. 3.2.2.1, IN ACCORDANCE WITH SE-019-066-2H	2.2.0			X		N/A	S	S	S	S	C
RECOVERY CENTER OF GRAVITY - CG AT VEHICLE STATION IN RANGE OF 56 - 59 PERCENT OF VEHICLE LENGTH	2.2.0			X		N/A	S	S	S	S	C
3.2 PERFORMANCE AND DESIGN CHARACTERISTICS											
3.2.1 MISSION PERFORMANCE											
3.2.1.1 MISSION OPERATIONS FUNCTIONS											
3.2.1.1.5 PROPELLANT DUMP - VERIFY CAPABILITY OF DUMPING PROPELLANTS TRAPPED IN THE MPS FEEDLINES AND MAIN ENGINE.		X			X	N/A	P	P	P	P	
41VV010 ESTABLISH TIME LINE FOR POST MECO PROPELLANT DUMP	5.4.6	X			X	N/A	P	P	S	S	
41VV007 MPS RELIEF VALVE VERIFICATION	5.3.3	X			X	N/A	S	S	S	S	C
ICD 13M15000											
PROPELLANT DUMPING, PARA. 4.5, PROPELLANT DUMP SEQUENCE, FLOWRATES AND CONSTRAINTS	5.4.6	X			X	N/A	P	P	P	P	

*S - SUCCESSFUL P - PARTIAL SUCCESS F - FAILURE C - COMPLETION OF REQUIREMENT VERIFICATION

TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.2.1.1.9 SHUTTLE VEHICLE SEPARATION - NOMINAL MODES - VERIFY SEPARATION SUBSYSTEMS PROVIDE FOR ELEMENT SEPARATION WITHOUT DAMAGE OR RECONTACT OF ELEMENTS.			X	X	X	N/A	S	S	S	S	C
41VV009 DEMONSTRATE ET SEPARATION EVENTS FOLLOW PLANNED SEQUENCE	5.4.5		X		X	N/A	S	S	S	S	C
47VB003 DEMONSTRATE SRB SEPARATION MOTOR PERFORMANCE	2.10.0			X		N/A	S	S	S	S	C
3.2.1.1.9.1.1.1 SEPARATION FLIGHT CONTROL FUNCTIONS - VERIFY SRB NOZZLES RETURN TO NULL POSITION FOR 5 SECONDS AFTER SEPARATION COMMAND.				X		N/A	S	S	S	S	C
47VB007 VERIFY SRB TVC SERVOACTUATOR PERFORMANCE TO DETERMINE RESPONSE, STABILITY, POSITIONING ACCURACY AND REDUNDANCY SCHEME OPERATION.	2.4.1			X		N/A	S	S	S	S	
3.2.1.1.9.1.1.3 BSM SYSTEM - VERIFY SRB BSM OPERATION OVER A PROPELLANT BULK TEMPERATURE RANGE OF 30 DEG F TO 120 DEG F.				X		N/A	S	S	S	S	C
47VB003 DEMONSTRATE SRB SEPARATION MOTOR PERFORMANCE	2.10.0			X		N/A	S	S	S	S	C
3.2.1.1.9.1.2 SRB SEPARATION SEQUENCE - RELEASE OF STRUCTURAL ATTACHMENTS SHALL OCCUR WITHIN 30 MS OF TIME SEPARATION COMMAND CROSSES ORB/SRB INTERFACE.	2.10.0			X		N/A	S	S	S	S	C
3.2.1.1.9.1.3 DESIGN SRB STAGING CONDITIONS - THE SRB SEPARATION SYSTEM SHALL PROVIDE SAFE SEPARATION FROM STAGING CONDITIONS WITHIN SPECIFIED LIMITS OF THE DEFINED PARAMETERS.				X		N/A	S	S	S	S	C
47VB017 VERIFY ADEQUACY OF PREFLIGHT ENTRY ANALYSES OF DYNAMIC PRESSURE AND VEHICLE MOTION FROM SEPARATION TO WATER IMPACT.	2.11.1			X		N/A	S	S	S	S	C
SRB CEI CP013M00000B											
SRB WILL BE CAPABLE OF WITHSTANDING MAXIMUM REENTRY ANGULAR RATES OF WX = 190 DEG/SEC, WY = 50 DEG/SEC, WZ = 50 DEG/SEC.	2.11.1			X		N/A	S	S	S	S	C

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS FLIGHT TEST REQUIREMENTS ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.2.1.1.9.2.2 ORBITER/ET SEPARATION SEQUENCE - ORBITER/ET SEPARATION SEQUENCE IS INITIATED WHEN MECO INITIATION IS VERIFIED. VERIFY PROPER ISSUANCE OF PIC ARM COMMAND, TIME SEQUENCED VALVE CLOSURE COMMANDS, ELECTRICAL DEADFACING COMMAND AND PIC FIRING COMMANDS.			X		X	N/A	S	S	S	S	C
41VV009 DEMONSTRATE SEPARATION EVENTS FOLLOW PLANNED SEQUENCE.	5.4.5		X		X	N/A	S	S	S	S	C
3.2.1.1.17 ET DISPOSAL - VERIFY NO ET IMPACT BELOW 60 DEG S PARALLEL AND NO CLOSER THAN 200 N.MI. FROM LAND MASSES. VERIFY ET TUMBLE SYSTEM OPERATION.			X			N/A	P	S	S	S	C
48VT009 VALIDATE PREDICTED ET TUMBLE RATE, BREAKUP ALTITUDE, AND RESULTANT FRAGMENTATION.	7.0		X			N/A	P	S	S	S	C
ET CEI, CPT01M26A TANK DEBRIS SHALL BE WITHIN FOOTPRINT OF 600 N.MI. ALONG TRACK AND 100 N.MI. CROSSTRACK.	7.0		X			N/A	S	S	S	S	C
3.2.1.2 ASSEMBLY AND LAUNCH FUNCTIONS											
3.2.1.2.3.1 CRYO LOADING MONITOR & CONTROL - SHUTTLE GROUND SYSTEM SHALL BE CAPABLE OF MONITORING AND REMOTELY CONTROLLING FUNCTIONS AND PARAMETERS CRITICAL TO PROPELLANT LOADING.			X		X	S	S	S	S	S	
41VV019 DEVELOP PROCEDURES TO FULFILL LO2 LOADING ACCURACY OF +/- .54 PERCENT.	5.3.1		X		X	S	S	S	S	S	
41VV019A DEVELOP PROCEDURES TO FULFILL LH2 LOADING ACCURACY OF +/- .69 PERCENT.	5.3.1		X		X	S	S	S	S	S	

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS		FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.2.1.2.7	<u>PROPELLANT FILL</u> - ET PROPELLANTS SHALL BE CAPABLE OF BEING LOADED AT THE MAXIMUM RATES OF 5000 GPM FOR LO2 AND 12000 GPM FOR LH2.			X		X	S	S	S	S	S	C
	41VV019 DEVELOP PROCEDURES TO FULFILL LO2 LOADING ACCURACY OF +/- .54 PERCENT.	5.3.1		X		X	S	S	S	S	S	
	41VV019A DEVELOP PROCEDURES TO FULFILL LH2 LOADING ACCURACY OF +/- .69 PERCENT.	5.3.1		X		X	S	S	S	S	S	
3.2.1.2.8	<u>PRELAUNCH PURGE</u> - ALL SHUTTLE ELEMENTS SHALL UTILIZE GSE AND FACILITIES TO MEET ALL PURGE REQUIREMENTS DURING PRELAUNCH PHASE.		X	X		X	S	S	S	S	S	C
	<u>OMRSD, FILE II</u>											
	S41000.M01, VERIFY ET LO2/LH2 FEED SYSTEM MOISTURE CONTENT AND CONTAMINATION LEVEL PRIOR TO LOADING CRYO'S.	5.2.1		X		X	S	S	S	S	S	C
	S05000.F03, VERIFY ET INTERTANK HAZARDOUS GAS CONCENTRATION	5.2.1		X		X	S	S	S	S	S	C
	S41000.F03, VERIFY MPS GN2 ENGINE PURGE REQUIREMENTS	5.2.1	X			X	S	P	S	S	S	C
	S41000.F14, VERITY ET INTERTANK COMPARTMENT TEMP BETWEEN 33 TO 118 DEG F PRIOR TO PROPELLANT LOADING.	5.2.1		X		X	S	S	S	S	S	C
3.2.2	DESIGN CHARACTERISTICS											
3.2.2.1	FLIGHT SYSTEMS DESIGN											
3.2.2.1.4	<u>POGO</u> - SHUTTLE VEHICLE SHALL BE FREE OF INSTABILITIES RESULTING FROM DYNAMIC COUPLING OF THE STRUCTURE, PROPULSION AND FLIGHT CONTROL SUBSYSTEMS.		X	X	X	X	N/A	S	S	S	S	C
	41VV024 VERIFY ABILITY TO MAINTAIN CORRECT LIQUID/GAS LEVEL IN THE ACCUMULATOR UNDER FLIGHT CONDITIONS.	5.7.0	X			X	N/A	S	S	S	S	C

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS FLIGHT TEST REQUIREMENTS ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.2.2.1.4.1 <u>POGO SUPPRESSOR REQUIREMENTS</u> - SEE ICD REQUIREMENTS BELOW.		X			X	S	S	S	S	S	C
41VV024 VERIFY ABILITY TO MAINTAIN CORRECT LIQUID/GAS LEVEL IN THE ACCUMULATOR UNDER FLIGHT CONDITIONS.	5.7.0	X			X	N/A	S	S	S	S	C
<u>ICD 13M15000, PARA 4.2.10.2</u>											
COMPLIANCE, SUPPRESSOR SHALL HAVE MINIMUM GAS VOLUME OF 0.6 FT3 AND PROVIDE COMPLIANCE GREATER THAN 0.045 IN2 OVER THE PRESSURE/TEMPERATURE OPERATING RANGE.	5.7.0	X			X	S	S	S	S	S	C
INERTANCE, SUPPRESSOR INERTANCE SHALL NOT EXCEED .0011 SEC2/IN2.	5.7.0	X			X	S	S	S	S	S	C
RESISTANCE, STEADY STATE PRESSURE DROP THROUGH ACCUMULATOR INLET PORT SHALL BE LESS THAN 1.25 PSI FOR A STEADY, 50 LB/SEC LO2 FLOW THROUGH SUPPRESSOR INLET PORT.	5.7.0	X			X	S	S	S	S	S	C
3.2.2.1.12 <u>TANK/LIQUID COUPLING</u> - TANKS SHALL PREVENT OR SUPPRESS COUPLING BETWEEN SLOSH OF LIQUIDS AND VEHICLE STRUCTURE, AND BETWEEN LIQUIDS AND FLIGHT CONTROL SUBSYSTEMS.			X			N/A	S	S	S	S	C
48VT007 VERIFY SPECIFICATIONS REQUIRING GUARANTEED VALUES OF SLOSH DAMPING IN THE ET LO2 TANK ARE MET.	3.2.0		X			N/A	S	S	S	S	C

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.2.2.1.13 PROPELLANT LOADING ACCURACIES - ROOT SUM SQUARE OVERALL SYSTEM LOADING ACCURACY TO 100% MASS LOAD LEVEL OF SHUTTLE SYSTEM SHALL BE +/- 0.5% FOR LO2 AND 0.69% FOR LH2.			X		X	S	S	S	S	S	
41VV019 DEVELOP PROCEDURES TO FULFILL LO2 LOADING ACCURACY.	5.3.1		X		X	S	S	S	S	S	
41VV019A DEVELOP PROCEDURES TO FULFILL LH2 LOADING ACCURACY.	5.3.1		X		X	S	S	S	S	S	
MC-1 VERIFY SHUTTLE VEHICLE PERFORMANCE IN FLIGHT ENVIRONMENT.	5.3.1		X		X	N/A	S	S	S	S	
3.2.2.1.15.1 O2 VENTING - THE LO2 TANK VENT VALVES SHALL PROVIDE ET RELIEF PROTECTION.			X		X	S	S	S	S	S	C
41VV003 DEMONSTRATE ABILITY TO MAINTAIN ET LO2 ULLAGE PRESSURE AT 20 TO 22 PSIG UNDER FLIGHT CONDITIONS.	5.4.4		X		X	N/A	S	S	S	S	C
ICD-2-12001											
LO2 TANK ULLAGE PRESSURE, PARA. 3.3.3.3, ULLAGE PRESSURE AT 20 TO 22 PSIG FOR BOTH ENGINE PRESTART AND OPERATION.	5.4.4		X		X	S	S	S	S	S	C
ICD 13M15000											
SSME/ORB PRESSURANT CRITERIA, PARA. 5.1, GOX FLOWRATE, TEMPERATURE AND PRESSURE LIMITS.	5.4.4	X			X	P	S	S	S	S	C
OMRSD, FILE II											
S00000.F01, LO2 TANK ULLAGE PRESSURE 3.3+/-1.7 PSIG PRIOR TO CRYO LOADING.	5.3.1		X		X	S	S	S	S	S	C
S41000.F20, LO2 TANK ULLAGE PRESSURE 5+/-3 PSIG DURING FAST FILL.	5.3.1		X		X	S	S	S	S	S	C
S41000.F38, LO2 TANK ULLAGE PRESSURE 5+/-3 PSIG DURING TOPPING.	5.3.1		X		X	S	S	S	S	S	C
S41000.F41, LO2 TANK ULLAGE PRESSURE 5+/-3 PSIG DURING REPLENISH.	5.3.1		X		X	S	S	S	S	S	C

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM: SSME	ET	SRB	MPS	STATUS PER STS NO.*: 0	1	2	3	4	OFT STATUS
3.2.2.1.15.2 H2 VENT - THE H2 VENT SYSTEM SHALL BE CAPABLE OF VENTING THE MAXIMUM STEADY-STATE BOIL OFF FROM THE H2 ET TO LIMIT THE TANK PRESSURE OF 16 PSIA MAX AT A MAX S.L. AMBIENT PRESSURE OF 15 PSIA DURING THE REPLENISH MODE OF THE TANKING OPERATION. FACILITY BACK PRESSURE AT THE FAC/ET INTERFACE SHALL NOT EXCEED 0.5 PSIG MAX AT A BOILOFF RATE OF 2.9 LB/SEC.			X		X	S	S	S	S	S	C
41VV004 DEMONSTRATE ABILITY TO MAINTAIN ET LH2 ULLAGE PRESSURE AT 41 TO 44 PSIA FOR PREPRESS AND 32 TO 34 PSIA FOR FLIGHT CONDITIONS.	5.3.1, 5.4.4		X		X	S	S	S	S	S	C
ICD-2-12001											
LH2 TANK ULLAGE PRESSURE, PARA. 3.3.2.3, A MINIMUM OF 38.5 PSIA WILL BE PROVIDED AT LIFTOFF PLUS ONE SECOND.	5.4.4		X		X	S	S	S	S	S	C
ICD 13M15000											
SSME/ORB PRESSURANT CRITERIA, PARA 5.1, GH2 FLOWRATE, TEMPERATURE AND PRESSURE LIMITS.	5.4.4	X			X	S	S	S	S	S	C
OMRSD, FILE II											
S00000.F01, LH2 TANK ULLAGE PRESSURE 18+/-1.7 PSIA PRIOR TO CRYO LOADING.	5.3.1		X		X	S	S	S	S	S	C
S41000.F32, LH2 TANK ULLAGE PRESSURE GREATER THAN 0 DURING CHILL; 15-20 PSIG DURING FILL; VENT TO 0.2 - 0.4 WHEN FULL.	5.3.1		X		X	S	S	S	S	S	C

*S - SUCCESSFUL P - PARTIAL SUCCESS F - FAILURE C - COMPLETION OF REQUIREMENT VERIFICATION

TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.2.2.1.17 DESIGN ENVIRONMENTS											
3.2.2.1.17.2 INDUCED ENVIRONMENT - EACH ELEMENT OF THE SHUTTLE FLIGHT VEHICLE SHALL BE CAPABLE OF WITHSTANDING THE INDUCED ENVIRONMENTS AS DEFINED IN APPENDIX 10.11.			X	X		S	S	S	S	P	
47VB001 VERIFY DESIGN AND TEST CRITERIA OF SRB TO PRECLUDE STRUCTURAL FAILURE DURING FLIGHT.	2.5.0, 2.6.0			X		N/A	S	S	S	P	
47VB002 VERIFY THE LOADS ANALYSIS TECHNIQUES AND THE DERIVED VEHICLE LOADS.	2.5.0			X		N/A	S	S	S	P	C
47VB008 VERIFY ADEQUACY OF LOADS ANALYSES TECHNIQUES AND THE DERIVED PRESSURE LOADS AT WATER IMPACT.	2.5.2			X		N/A	P	P	S	F	
47VB009 DETERMINE ACOUSTIC ENVIRONMENTS DURING HOLDDOWN, ASCENT, AND ENTRY.	2.6.2			X		N/A	P	P	S	P	
47VB012 DETERMINE INTERNAL AND EXTERNAL PRESSURES ON NOSE CONE, FORWARD AND AFT SKIRTS FOR VENTING ASSESSMENTS.	2.6.1			X		N/A	P	S	S	P	
47VB015 VERIFY THE ADEQUACY OF THE SRB STRUCTURAL THERMAL DESIGN AND THERMAL ENVIRONMENT USED FOR TEST CRITERIA.	2.7.0, 2.8.1			X		N/A	S	S	S	P	
48VT001 DEMONSTRATE PERFORMANCE OF ET THERMAL PROTECTION SYSTEM AND VERIFY ET THERMAL MODEL.	3.5.2		X			N/A	S	S	S	S	
48VT002 VERIFY THERMAL AND PRESSURE ENVIRONMENT OF ET NOSE CAP AND INTERTANK FOR VENTING ANALYSIS.	3.4.1, 3.5.3		X			N/A	S	S	S	S	
48VT003 VERIFY ET/ORB INTERFACE, ET/SRB INTERFACE AND LIQUID HYDROGEN TANK LOADS.	3.3.0		X			N/A	S	S	S	P	C
48VT004 VERIFY LOADS ANALYSIS TECHNIQUES AND THE DERIVED VEHICLE LOADS.	3.3.0		X			N/A	P	S	S	S	C
48VT005 VERIFY THE DESIGN AND VIBRATION TEST CRITERIA FOR THE ET.	3.4.2		X			N/A	S	S	S	S	
48VT006 VERIFY THE ACOUSTIC ENVIRONMENT AND CRITERIA FOR THE EXTERNAL TANK.	3.4.2		X			N/A	S	S	S	S	

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS FLIGHT TEST REQUIREMENTS ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
SRB CEI, CP013M00000B											
LOADING CONDITIONS, PARA 3.2.1.1.4, VERIFY STRESSES IN SRM AND AFT ATTACH STRUTS DO NOT EXCEED DESIGN LIMITS IN SE-019-057-2H.	2.5.1			X		S	S	S	S	P	C
ASCENT, PARA 3.2.1.1.4.3, SRB SHALL BE CAPABLE OF ASCENT FLIGHT UNDER THE DEFINED INDUCED ENVIRONMENTS.	2.5.1, 2.6.0			X		N/A	S	S	S	S	C
REENTRY, PARA. 3.2.1.1.4.4, SRB SHALL BE CAPABLE OF REENTRY UNDER THE DEFINED INDUCED ENVIRONMENTS.	2.5.2, 2.6.0			X		N/A	P	P	P	F	
RECOVERY, PARA. 3.2.1.1.4.5.1, SRB SHALL BE CAPABLE OF RECOVERY UNDER THE DEFINED INDUCED ENVIRONMENTS.	2.5.2			X		N/A	P	P	P	F	
VENTING, PARA. 3.3.6.15, VERIFY THAT INTERNAL LIMIT PRESSURES DEFINED IN SE-019-057-2H ARE NOT EXCEEDED (WHERE INSTRUMENTATION IS AVAILABLE)	2.6.1			X		N/A	S	S	S	S	C
ICD-2-12001											
UMBILICAL PLATE LOADS, PARA. 3.2.3, LIMIT LOADS AT ET/ORB INTERFACE DEFINED IN TABLE 3.2.3-1.	3.3.0		X			S	S	S	S	S	C
LIQUID LEVEL POINT SENSOR SIGNAL CONDITIONING, PARA 3.4.6.2.1, ELECTRONIC PACKAGE SHALL BE CAPABLE OF WITHSTANDING A TEMPERATURE RANGE OF 130 DEG F TO -65 DEG F.	3.5.3		X			S	S	S	S	S	C
3.2.2.1.17.2.1 ASCENT HEATING DESIGN CRITERIA - THE SHUTTLE ELEMENTS SHALL BE CAPABLE OF WITHSTANDING THE ASCENT AERODYNAMIC HEATING ENVIRONMENT AS DEFINED IN APPENDIX 10.11.		X	X	X		N/A	S	S	S	S	
47VB015 VERIFY THE ADEQUACY OF THE SRB STRUCTURAL THERMAL DESIGN AND THERMAL ENVIRONMENT USED FOR TEST CRITERIA.	2.8.1, 6.2.0			X		N/A	S	S	S	P	
48VT001 DEMONSTRATE PERFORMANCE OF ET THERMAL PROTECTION SYSTEM AND VERIFY ET THERMAL MODEL.	3.5.2, 6.3.0		X			N/A	S	S	S	S	

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.3 SHUTTLE VEHICLE END ITEM PERFORMANCE AND DESIGN CHARACTERISTICS											
3.3.1 ORBITER VEHICLE CHARACTERISTICS											
3.3.1.2 ORBITER DESIGN CHARACTERISTICS											
3.3.1.2.2 PROPULSION											
3.3.1.2.2.1 MAIN PROPULSION SYSTEM - THE ORBITER VEHICLE MPS ASSISTED BY TWO SRBS... SHALL PROVIDE VELOCITY INCREMENT AND THRUST VECTOR CONTROL... WITH A MAXIMUM SSME GIMBAL DEFLECTIONS OF +/- 11 DEGREES IN PITCH AND +/- 9 DEGREES IN YAW.		X	X	X	X	N/A	S	S	S	S	S
41VV023 VERIFY CAPABILITY TO ACCURATELY PREDICT MPS FLIGHT PERFORMANCE AND ASSURE MPS PERFORMANCE WITHIN PRESCRIBED ACCEPTABLE LIMITS.	5.4.1, 5.4.2, 5.4.3				X	S	P	P	P	P	
47VB007 VERIFY SRB TVC SERVOACTUATOR PERFORMANCE IN FLIGHT ENVIRONMENT TO DETERMINE RESPONSE, STABILITY, POSITIONING ACCURACY AND REDUNDANCY SCHEME OPERATION.	2.4.1			X		N/A	S	S	S	S	
47VB010 DEMONSTRATE ADEQUATE SRB PROPULSION SYSTEM PERFORMANCE.	2.3.0			X		N/A	S	S	S	S	
MC-1 VERIFY SHUTTLE VEHICLE PERFORMANCE (INJECTED WEIGHT)	2.3.0,			X		N/A	S	S	S	S	
IN THE FLIGHT ENVIRONMENT.	5.4.2				X	N/A	S	S	S	S	
<u>SRB CEI, CP013M00000B</u>											
IGNITION INTERVAL, PARA. 3.2.1.6.2.1, SRM IGNITION INTERVAL SHALL BE BETWEEN 170 AND 340 MS AFTER IGNITION COMMAND.	2.3.0			X		N/A	S	S	S	S	C
PRESSURE RISE RATE, PARA. 3.2.1.6.2.1, MAX RATE OF HEAD END CHAMBER PRESSURE BUILDUP SHALL BE 109 PSI FOR ANY 10 MILLISECOND INTERVAL.	2.3.0			X		N/A	S	S	S	S	C

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS FLIGHT TEST REQUIREMENTS ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
THRUST DIFFERENTIAL, PARA. 3.2.1.6.2.4, IGNITION THRUST IMBALANCE, STEADY STATE THRUST IMBALANCE, AND TAILOFF THRUST IMBALANCE.	2.3.0			X		N/A	S	S	S	S	C
PERFORMANCE TOLERANCES, PARA. 3.2.1.6.2.2.3, SHALL NOT EXCEED TOLERANCES LISTED IN TABLE 3-2.	2.3.0			X		N/A	S	S	S	S	C
ICD 13M15000											
ENGINE STARTING TIME, PARA. 4.1.4, DEPICTED IN FIG. 4.1.4-1 OF SOURCE DOCUMENT.	5.4.1	X			X	S	S	S	S	S	C
ENGINE START PROPELLANT CONSUMPTION, PARA. 4.1.5, PROPELLANTS CONSUMED DURING START SHOWN IN FIGURE 4.1.5-1.	5.4.1	X			X	S	S	S	S	S	C
ENGINE OPERATING CONDITIONS, PARA. 4.2.4, THRUST, SPECIFIC IMPULSE AND INLET FLOWRATES.	5.4.2	X			X	S	P	P	P	P	
STEP COMMAND RESPONSE, PARA. 4.2.6, ENGINE THRUST CHANGE LIMITS.	5.4.2	X			X	S	S	S	S	S	C
ENGINE SHUTDOWN IMPULSE, PARA 4.3.1, SHALL NOT EXCEED THAT SHOWN IN FIGURE 4.3.1-1.	5.4.3	X			X	S	S	S	S	S	C
ENGINE SHUTDOWN TIME, PARA. 4.3.2, SHALL NOT EXCEED THAT SHOWN IN FIGURE 4.3.1-1.	5.4.3	X			X	S	S	S	S	S	C
PROPELLANT CONSUMPTION, PARA. 4.3.3, PROPELLENTS CONSUMED DURING SHUTDOWN ARE SHOWN IN FIGURE 4.1.5-1.	5.4.3	X			X	S	S	S	S	S	C
SHUTDOWN REQUIREMENTS, PARA 4.3.4, MPL WILL BE MAINTAINED A MINIMUM OF TWO SECONDS PRIOR TO SHUTDOWN COMMAND.	5.4.3	X			X	N/A	S	S	P	S	C
SHUTDOWN FLOW DECELERATIONS, PARA 4.3.5, ENGINE SHALL NOT GENERATE FLOW DECELERATIONS GREATER THAN SHOWN IN FIGURE 4.3.5-1.	5.4.3	X			X	S	S	S	S	S	C

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.3.1.2.5 ORBITER POWER											
3.3.1.2.5.1 ELECTRICAL POWER SUBSYSTEM - THE ELECTRICAL POWER SUBSYSTEM SHALL GENERATE THE ELECTRICAL POWER REQUIRED FOR ALL ORBITER VEHICLE SUBSYSTEMS.			X	X		S	S	S	S	S	C
47VB004 DEMONSTRATE ADEQUATE PERFORMANCE OF THE SRB ELECTRICAL POWER SYSTEM.	2.9.1			X		S	S	S	S	S	C
47VB013 DETERMINE OPERATING ENVIRONMENT OF THE DFI EQUIPMENT AND ITS EFFECT ON DATA SYSTEM ACCURACY.	2.9.1			X		S	S	S	S	S	C
48VT008 VALIDATE ET ELECTRICAL SYSTEM PERFORMANCE DURING FLIGHT.	3.6.1		X			S	S	S	S	S	C
ICD-2-14001 PARA. 3.1, CHARACTERISTICS OF ELECTRICAL POWER SUPPLIED TO EACH SRB.	2.9.1			X		S	S	S	S	S	C
ICD-2-12001 PARA. 3.4.1, CHARACTERISTICS OF DFI AND TUMBLING SYSTEM POWER.	3.6.1		X			S	S	S	S	S	C
ET CEI, MMC-ET-CM02A-A TWO (2) VOLT DROP ALLOWED FROM THE INTERFACE WITH THE ORBITER TO THE DFI BUS IN ET I/T.	3.6.1		X			S	S	S	S	S	C
3.3.1.3 ORBITER INTERFACE CHARACTERISTICS											
3.3.1.3.1 ORBITER INTERFACE WITH EXTERNAL TANK - THE ORBITER VEHICLE SHALL INTERFACE WITH THE ET AS DEFINED IN ICD-2-12001.					X	S	S	S	S	S	C
41VV005 VERIFY THAT THE PROPELLANT CONDITIONS AT THE ET LO2 DISCHARGE DURING MAINSTAGE ARE WITHIN SPECIFIED LIMITS.	5.3.3				X	S	S	S	S	S	C
41VV006 VERIFY THAT THE PROPELLANT CONDITIONS AT THE ET LH2 DISCHARGE DURING MAINSTAGE ARE WITHIN SPECIFIED LIMITS.	5.3.3				X	S	S	S	S	S	C
3.3.1.3.2 ORBITER INTERFACE WITH SOLID ROCKET BOOSTER											

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS		FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.3.1.3.2.1	ASCENT GUIDANCE AND CONTROL - FLIGHT CONTROL SHALL BE PERFORMED JOINTLY BY THE ORBITER VEHICLE AND THE SRB'S FROM LIFTOFF TO STAGING. THE ORBITER SHALL PROVIDE STEERING COMMANDS TO THE SRB TVC.				X		N/A	S	S	S	S	
47VB007	VERIFY SRB TVC SERVOACTUATOR PERFORMANCE TO DETERMINE RESPONSE, STABILITY, POSITIONING ACCURACY, AND REDUNDANCY SCHEME OPERATION.	2.4.1			X		N/A	S	S	S	S	
3.3.1.3.4	ORBITER VEHICLE INTERFACE WITH MAIN ENGINE - THE ORBITER VEHICLE SHALL INTERFACE WITH THE MAIN ENGINES AS DEFINED IN ICD 13-M-15000.					X	S	S	S	S	S	C
41VV005	VERIFY THAT THE PROPELLANT CONDITIONS AT THE LO2 ENGINE INLETS ARE WITHIN SPECIFIED LIMITS.	5.3.3				X	S	S	S	S	S	C
41VV006	VERIFY THAT THE PROPELLANT CONDITIONS AT THE LH2 ENGINE INLETS ARE WITHIN SPECIFIED LIMITS.	5.3.3				X	S	S	S	S	S	C
3.3.2	SOLID ROCKET BOOSTER (SRB) CHARACTERISTICS											
3.3.2.1	SRB PERFORMANCE CHARACTERISTICS											
3.3.2.1.1	SRB ASCENT - THE SRB'S IN PARALLEL WITH SSME'S SHALL PROVIDE IMPULSE AND TVC TO THRUST THE FLIGHT VEHICLE FROM LIFTOFF TO SRB STAGING.				X		N/A	S	S	S	S	
47VB007	VERIFY SRB TVC SERVOACTUATOR PERFORMANCE TO DETERMINE RESPONSE, STABILITY, POSITIONING ACCURACY, AND REDUNDANCY SCHEME OPERATION.	2.4.1			X		N/A	S	S	S	S	
47VB010	DEMONSTRATE ADEQUATE SRB PROPULSION SYSTEM PERFORMANCE.	2.3.0			X		N/A	S	S	S	S	
MC-1	VERIFY SHUTTLE VEHICLE PERFORMANCE (INJECTED WEIGHTS) IN THE FLIGHT ENVIRONMENT.	2.3.0			X		N/A	S	S	S	S	

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
SRB CEI, CP013M00000B											
IGNITION INTERVAL, PARA. 3.2.1.6.2.1, INTERVAL SHALL BE BETWEEN 170 AND 340 MS AFTER IGNITION COMMAND.	2.3.0			X		N/A	S	S	S	S	C
PRESSURE RISE RATE, PARA. 3.2.1.6.2.1, MAXIMUM RATE FOR PRESSURE BUILDUP SHALL BE 109 PSI FOR ANY 10 MS INTERVAL.	2.3.0			X		N/A	S	S	S	S	C
THRUST DIFFERENTIAL, PARA. 3.2.1.6.2.4, IGNITION THRUST IMBALANCE, STEADY STATE THRUST IMBALANCE AND TAILOFF THRUST IMBALANCE.	2.3.0			X		N/A	S	S	S	S	C
PERFORMANCE TOLERANCES, PARA 3.2.1.6.2.2.3, SHALL NOT EXCEED TOLERANCES IN TABLE 3-2.	2.3.0			X		N/A	S	S	S	S	C
3.3.2.1.2 SRB PERFORMANCE REQUIREMENTS - THE NOMINAL VACUUM THRUST-TIME CURVE SHALL FALL WITHIN THE LIMITS ILLUSTRATED ON FIGURE 3.3.2.1.2A AND TABULATED IN TABLE 3.3.2.1.2A. THE NOMINAL SRM VACUUM IMPULSE SHALL MEET THE REQUIREMENTS ON FIGURE 3.3.2.1.2A.				X		N/A	S	S	S	S	
47VB010 DEMONSTRATE ADEQUATE SRB PROPULSION SYSTEM PERFORMANCE.	2.3.0			X		N/A	S	S	S	S	
MC-1 VERIFY SHUTTLE VEHICLE PERFORMANCE (INJECTED WEIGHTS) IN THE FLIGHT ENVIRONMENT.	2.3.0			X		N/A	S	S	S	S	
SRB CEI, CP013M00000B											
IGNITION INTERVAL, PARA. 3.2.1.6.2.1, INTERVAL SHALL BE BETWEEN 170 AND 340 MS AFTER IGNITION COMMAND.	2.3.0			X		N/A	S	S	S	S	C
PRESSURE RISE RATE, PARA 3.2.1.6.2.1, MAXIMUM RATE FOR PRESSURE BUILDUP SHALL BE 109 PSI FOR ANY 10 MS INTERVAL.	2.3.0			X		N/A	S	S	S	S	C
THRUST DIFFERENTIAL, PARA. 3.2.1.6.2.4, IGNITION THRUST IMBALANCE, STEADY STATE THRUST IMBALANCE AND TAILOFF THRUST IMBALANCE.	2.3.0			X		N/A	S	S	S	S	C
PERFORMANCE TOLERANCES, PARA 3.2.1.6.2.2.3, SHALL NOT EXCEED TOLERANCES IN TABLE 3-2.	2.3.0			X		N/A	S	S	S	S	C
3.3.2.2 SRB DESIGN CHARACTERISTICS											
3.3.2.2.1 EXTERNAL CONFIGURATION											

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS FLIGHT TEST REQUIREMENTS ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.3.2.2.1.4 THRUST VECTOR CONTROL - THE SRB TVC SUBSYSTEM IN CONJUNCTION WITH THE SRM SHALL BE CAPABLE OF PROVIDING PITCH, ROLL, AND YAW VEHICLE MOVEMENTS...				X		N/A	S	S	S	S	
47VB007 VERIFY SRB TVC SERVOACTUATOR PERFORMANCE TO DETERMINE RESPONSE, STABILITY, POSITIONING ACCURACY, AND REDUNDANCY SCHEME OPERATION.	2.4.1			X		N/A	S	S	S	S	
47VB011 DEMONSTRATE ADEQUATE INFLIGHT PERFORMANCE OF THE THRUST VECTOR CONTROL POWER SUPPLY.	2.4.2			X		N/A	S	S	S	S	C
SRB CEI, CP013M00000B HYDRAULIC POWER SUPPLY, PARA. 3.2.1.7.1.3, VERIFY THE FOLLOWING PRE-APU START LEVEL HYDRAULIC FLUID RSVR SHALL BE 60-80% (70 +/- 5% FOR STS-0) N2 5H445 GN2 BOTTLE OUTLET PRESSURE 385 PSIA +/- 10 PSIA AT 70 DEG F N2 5H445 GN2 BOTTLE GAS TEMPERATURE SHALL BE 45-139.5 DEG F GAS GENERATOR BED TEMPERATURE SHALL BE 219 +/- 29 DEG F DURING OPERATION APU TURBINE SPEED SHALL BE 72,000 +/- 5760 RPM HYDRAULIC FLUID SUPPLY PRESSURE SHALL BE 3125 +/- 125 PSIA	2.4.2			X		P	S	S	S	S	C
3.3.2.2.3 SRB DESTRUCT SYSTEM - THE SRB'S SHALL BE PROVIDED WITH GROUND COMMANDED SYSTEMS TO DESTRUCT THE SRB'S.				X		N/A	S	S	S	S	
47VB014 MONITOR AND VERIFY PERFORMANCE AND STATUS OF THE RANGE SAFETY SYSTEM DURING PRELAUNCH AND FLIGHT OPERATIONS.	8.0			X		N/A	S	S	S	S	
SRB CEI, CP013M00000B DESTRUCT SAFING, PARA 3.2.6.7.2, THE SRB DESTRUCT SYSTEMS SHALL BE SAFED ELECTRONICALLY AND MECHANICALLY PRIOR TO NORMAL SRB SEPARATION...	8.0			X		N/A	S	S	S	S	

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TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONTINUED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS	FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.3.3 EXTERNAL TANK CHARACTERISTICS											
3.3.3.2 EXTERNAL TANK DESIGN CHARACTERISTICS											
3.3.3.2.4 PROPELLANT SLOSH DAMPING - VERIFY ET PROVIDES DAMPING OF THE LO2 TANK WITHIN LIMITS OF TABLE 3.3.3.2.4 IN VOL. X.			X			N/A	S	S	S	S	C
47VT007 VERIFY SPECIFICATIONS REQUIRING GUARANTEED VALUES OF SLOSH DAMPING IN THE ET LO2 TANK ARE MET.	3.2.0		X			N/A	S	S	S	S	C
3.3.3.2.6 THERMAL PROTECTION - ET THERMAL DESIGN SHALL ASSURE THAT THE EXTERNAL SURFACE DOES NOT GO BELOW 32 DEG F UNDER TBD ATMOSPHERIC CONDITIONS. (SPECIFIED BY JSC)			X			S	S	S	S	S	
48VT001 DEMONSTRATE ADEQUATE PERFORMANCE OF THE ET THERMAL PROTECTION SYSTEM DURING ASCENT AND VERIFY THERMAL MODEL.	3.5.0		X			N/A	S	S	S	S	
3.3.3.2.8 SAFE SEPARATION DISTANCE - TO INSURE A MINIMUM SAFE SEPARATION DISTANCE BETWEEN THE ORBITER AND THE ET OF 4 N.MI., FOR NOMINAL MISSION THE ET SHALL NOT RUPTURE UNTIL AFTER ENTRY BELOW 350 KFT.			X			N/A	S	S	S	S	C
48VT009 VALIDATE PREDICTED ET TUMBLE RATE, BREAKUP ALTITUDE, AND RESULTANT FRAGMENTATION.	7.0		X			N/A	P	S	S	S	C
3.3.4 MAIN ENGINE CHARACTERISTICS - THE SPACE SHUTTLE MAIN ENGINE SHALL MEET THE REQUIREMENTS SPECIFIED IN 3.3.4.1.1, 3.3.4.1.2, AND ICD 13M15000.			X		X	S	P	P	P	P	
ICD 13M15000 SEE ICD 13M15000 REQUIREMENTS DEFINED UNDER 3.3.1.2.2.1	5.4.0	X			X	S	P	P	P	P	

*S - SUCCESSFUL P - PARTIAL SUCCESS F - FAILURE C - COMPLETION OF REQUIREMENT VERIFICATION

TABLE 1.3-1 MSFC SPACE SHUTTLE FLIGHT EVALUATION
SPECIFICATION REQUIREMENTS & FLIGHT TEST REQUIREMENTS (CONCLUDED)

JSC 00770-X SPECIFICATION REQUIREMENTS / FLIGHT TEST REQUIREMENTS / ICD/CEI SPECIFICATIONS		FER SECTION	MSFC RESPONSIBLE ELEMENT/SYSTEM SSME	ET	SRB	MPS	STATUS PER STS NO.* 0	1	2	3	4	OFT STATUS
3.3.4.1	MAIN ENGINE PERFORMANCE CHARACTERISTICS											
3.3.4.1.1	ENGINE PERFORMANCE LEVELS - VERIFY SINGLE ENGINE PERFORMANCE THRUST, MIXTURE RATIO, SPECIFIC IMPULSE.		X			X	S	P	P	P	P	
	41VV023 VERIFY THE CAPABILITY TO ACCURATELY PREDICT THE MPS FLIGHT PERFORMANCE AND ASSURE MPS PERFORMANCE WITHIN PRESCRIBED ACCEPTABLE LIMITS.	5.4.2	X			X	S	P	P	P	P	
3.3.4.1.2	ENGINE OPERATING CONDITIONS - THE ENGINE OPERATING CONDITIONS FOR THRUST, SPECIFIC IMPULSE, AND MIXTURE RATIO ARE GIVEN IN TABLE 3.3.4.1.2.		X			X	S	P	P	P	P	
	41VV023 VERIFY THE CAPABILITY TO ACCURATELY PREDICT THE MPS FLIGHT PERFORMANCE AND ASSURE MPS PERFORMANCE WITHIN PRESCRIBED ACCEPTABLE LIMITS.	5.4.2	X			X	S	P	P	P	P	
3.5	OPERABILITY											
3.5.3	USEFUL LIFE											
3.5.3.1	REUSE											
3.5.3.1.2	ET - THE ET IS NOT REUSABLE AND SHALL BE CAPABLE OF A SINGLE VERTICAL LAUNCH.			X			N/A	S	S	S	S	C
3.5.3.1.3	SRB - EACH SRB SHALL BE CAPABLE OF A MINIMUM OF 20 VERTICAL LAUNCHES WITH RECOVERY, RETRIEVAL AND REFURBISHMENT AFTER EACH MISSION.				X		N/A	S	S	S	F	
3.5.3.1.5	SSME - THE SSME SHALL BE CAPABLE OF A SERVICE LIFE, BETWEEN OVERHAUL, OF 55 STARTS OR 7 1/2 HOURS TOTAL TIME INCLUDING NOT MORE THAN 14,000 SECONDS AT FPL.		X				S	S	S	S	S	

*S - SUCCESSFUL P - PARTIAL SUCCESS F - FAILURE C - COMPLETION OF REQUIREMENT VERIFICATION

2.0 SOLID ROCKET BOOSTER

2.1.0 SRB FLIGHT SUMMARY - This subsection provides a summary of the significant evaluation results relative to the SRB during STS-4.

2.1.1 SRB FLIGHT OBJECTIVES AND ACCOMPLISHMENTS - Table 2.1.1-1 summarizes the STS-4 objectives pertaining to the SRB along with the degree of accomplishment and discrepancies for each objective.

TABLE 2.1.1-1 SRB OBJECTIVES AND ACCOMPLISHMENTS

OBJECTIVES	DEGREE OF ACCOMPLISHMENT	DISCREPANCIES
EVALUATE SRB MASS PROPERTIES, RECONSTRUCT MASS PROPERTIES - COMPARE TO PREDICTED DATA AND PREDICTED DISPERSIONS AT SIGNIFICANT FLIGHT EVENTS.	COMPLETE	NONE
EVALUATE SRM PROPULSION PERFORMANCE. COMPARE TO PREFLIGHT PREDICTION.	COMPLETE	NONE
VERIFY TVC SERVOACTUATOR PERFORMANCE DURING FLIGHT. VERIFY TVC HYDRAULIC POWER SUBSYSTEM PERFORMANCE WAS WITHIN DESIGN LIMIT.	COMPLETE	NONE
VERIFY DESIGN LIMITS LOADS WERE NOT EXCEEDED DURING LIFTOFF, ASCENT, SEPARATION, PARACHUTE DEPLOYMENT, DESCENT AND WATER IMPACT. VERIFY STRESSES IN THE SRM AND AFT ATTACH STRUTS WERE NOT EXCEEDED DURING IGNITION, HOLDDOWN, FLIGHT AND RECOVERY.	ASCENT-COMPLETE REENTRY-INCOMPLETE IMPACT-INCOMPLETE	NONE BOTH SRBs LOST AT WATER IMPACT
VERIFY PRESSURES ON THE SRB DID NOT EXCEED DESIGN CRITERIA DURING HOLDDOWN, ASCENT AND REENTRY. VERIFY SRB STRUCTURAL VIBRATION ENVIRONMENT & INTERNAL ACOUSTIC ENVIRONMENT. VERIFY E&I AND MECHANICAL COMPONENTS DESIGN CRITERIA WERE NOT EXCEEDED.	ASCENT - INCOMPLETE REENTRY - INCOMPLETE	DATA NOT AVAILABLE
VERIFY THAT THE AERODYNAMIC HEATING ENVIRONMENT OF THE SRB WAS WITHIN DESIGN LIMITS DURING ASCENT AND REENTRY.	INCOMPLETE	DATA NOT AVAILABLE
EVALUATE THE TPS PERFORMANCE AND VERIFY ALL PRIMARY SRB STRUCTURES AND SUBSYSTEM COMPONENTS DID NOT EXPERIENCE TEMPERATURES BEYOND DESIGN LIMITS.	PARTIAL	DUE TO LOSS OF SRB DATA RECORDERS TEMPERATURE LIMITS HAVE NOT BEEN VERIFIED.
EVALUATE THE PERFORMANCE OF THE RANGE SAFETY SYSTEM, DURING ALL PHASES OF FLIGHT.	COMPLETE	NONE
VERIFY BSM PERFORMANCE, VERIFY RELEASE OF ALL SRB STRUCTURAL ATTACHMENTS IN REQUIRED TIME PERIOD.	PARTIAL	BSM PRESSURE DATA NOT AVAILABLE
VERIFY SRB REENTRY TRAJECTORY AND ATTITUDE AND VERIFY PERFORMANCE OF RECOVERY SYSTEM.	PARTIAL	ALL MAIN PARACHUTES FAILED ON BOTH SRBs AFTER DROGUE CHUTE DEPLOYMENT. BOTH SRBs WERE LOST AFTER SPLASHDOWN.

2.1.2 SRB CONFIGURATION DESCRIPTION SUMMARY – Figure 2.1.2-1 presents the SRB configuration for STS-4.

As a result of probability of main chute damage at deployment, the main chute floats were disconnected. One deck fitting remained attached to prevent loss of the main chutes after splashdown. Also, the main parachute first stage reefed area was increased to balance first and second stage loads.

The following changes were made to the TVC:

- o Accumulator added in TVC hydraulic system to increase system stability.
- o APU "purge in" flex hose was re-added.

Insulation on nose cap was changed from bonded cork to sprayable ablator.

Additional ring reinforcement was made on aft skirt rings to reduce water impact damage.

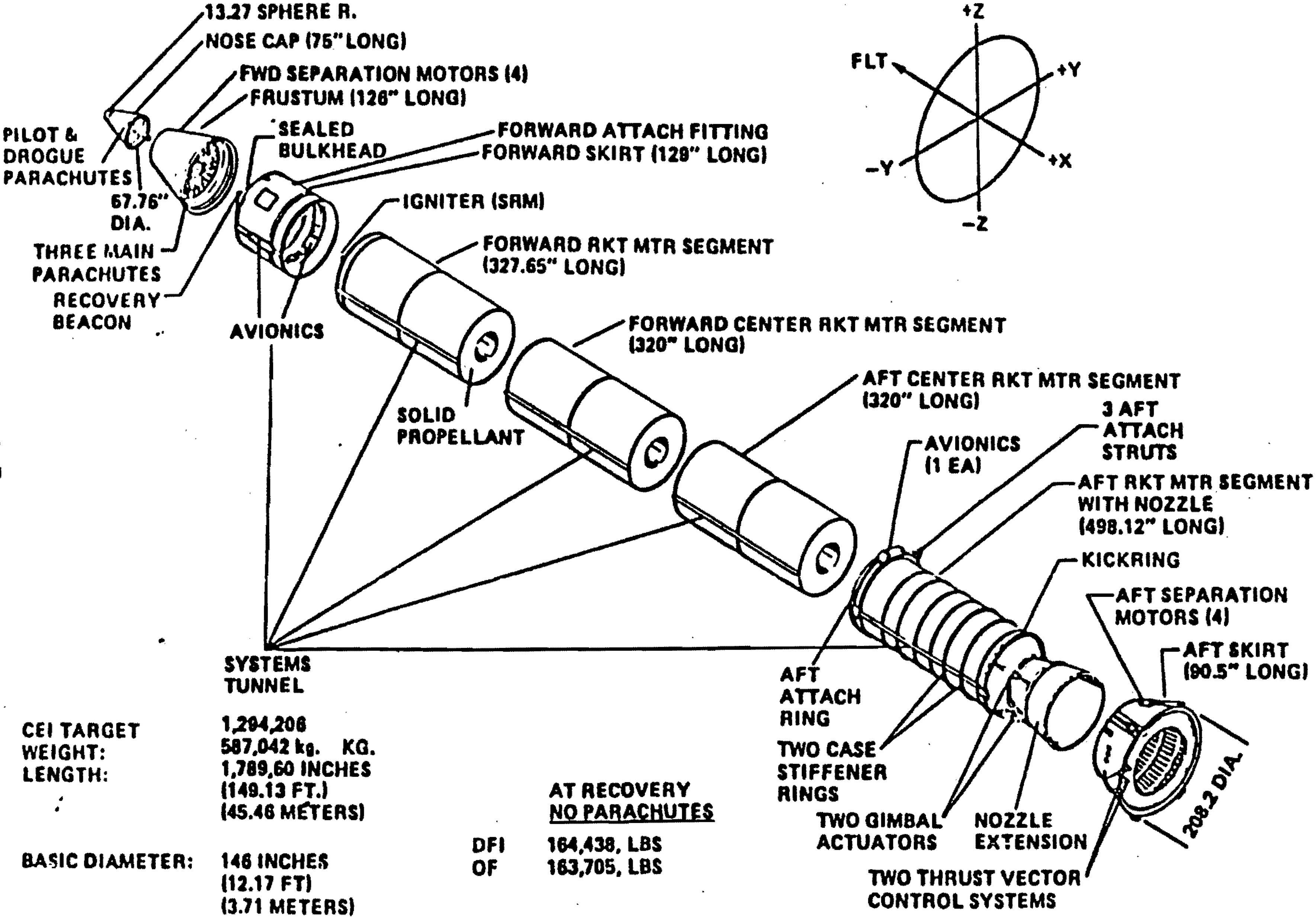


FIGURE 2.1.2.-1 SRB CONFIGURATION

2.1.3 SRB SIGNIFICANT EVENT TIMES - Table 2.1.3-1 lists the SRB significant event times for STS-4, relative to the SRB ignition command (82:178:14:59:59.793 GMT). The actual, predicted and delta times are shown along with the event description and number. A reference time of 1982:178:14:59:59.000 GMT was established for STS-4 data reduction purposes and is referred to in this report as the "GMT REFERENCE TIME". Data resolution for the STS-4 SRB significant event times is not consistent with that of previous flights. (Note: Item 8 - SRB Ignition PICs are replaced by KSC Holddown PICs.)

TABLE 2.1.3-1 SRB SIGNIFICANT EVENT TIMES

ITEM	EVENT DESCRIPTION	MSID/SOURCE	TIME FROM SRB IGN CMND* (SEC) ACTUAL	PREDICTED	DIFF.**
1	SRB IGN S&A DEVICE ARM	B55X1842X	-297.634	-299.000	1.366
		B55X1843X	-297.634	-299.000	1.366
		B55X2842X	-297.234	-299.000	1.766
		B55X2843X	-297.634	-299.000	1.366
2	SRB FLT RECORDER IND ON	B78X7888A	-47.234	-50.000	2.766
		B78X8888X	-46.234	-50.000	3.766
3	FDM AUTO CAL	B78X7926X	-39.234	-39.000	-.234
		B78X8926X	-39.234	-39.000	-.234
4	SRB HPU ACTIVATION CMD RESPONSE TIME	B58K3017X	-27.644	-28.000	.356
		B58K3019X	-27.404	-28.000	.596
		B58K4017X	-27.324	-28.000	.676
		B58K4019X	-27.164	-28.000	.836
5	IGN PIC A&B ARM CMD	B55V1603C	-17.234	-18.000	.766
		B55V1604C	-17.234	-18.000	.766
		B55V2603C	-17.234	-18.000	.766
		B55V2604C	-17.234	-18.000	.766
6	E-3 START CMD ACCEPTED	E41M3076D	-6.310		
7	SRB IGNITION CMD	GPC	.000		
8	KSC HOLD DOWN PICS	GMSV130XA	.017	.010	.007
		GMSV230XA	.013	.010	.003
9	LIFTOFF	3.8M LBS SRM THRUST		.230	
10	SHUTTLE MAX Q	BET	71.000	65.000	6.000
11	BOTH SRMs PC 50 PSIA OR BELOW	V90P2535C V90P2536C	123.900	120.170	3.730
12	SRM NOZZLE NULL CMD	V79H2110A	128.209	124.470	3.739
		V79H2111A	128.210	124.470	3.740
		V79H2130A	128.210	124.470	3.740
		V79H2131A	128.213	124.470	3.743
13	SRB PHYSICAL SEPARATION	LH SRB	129.979	126.170	3.809
		RH SRB	129.981	126.170	3.811
14	LH RECOVERY PIC ARM	B52X7884E		156.170	
15	RH RECOVERY PIC ARM	B52X8884E		156.170	
16	RE-ENTRY MAX Q (NOM)	LH SRB BET	315.800	314.000	1.800
		RH SRB BET	314.200	314.000	.200
17	LH HI ALT BARO SW CLOSED	B55V1617A		346.070	
18	RH HI ALT BARO SW CLOSED	B55V2617A		346.070	
19	LH LO ALT BARO SW CLOSED	B55V1618A		367.820	
20	RH LO ALT BARO SW CLOSED	B55V2618A		367.820	
21	LH NOZZLE JETTISON CMD	B52X7897E		387.320	
22	RH NOZZLE JETTISON CMD	B52X8897E		387.320	
23	LH SRB IMPACT	B52X7886E		400.830	
24	RH SRB IMPACT	B52X8886E		400.830	
25	LH RECOVERY SYS PWR OFF	B52X7885E		400.830	
26	RH RECOVERY SYS PWR OFF	B52X8885E		400.830	

* 1982:178:14:59:59.793 GMT
** DIFF. - ACTUAL - PREDICTED

2.1.4 SRB FAILURES, ANOMALIES AND RECOMMENDED ACTION - There were two anomalies associated with the SRB during STS-4: (1) The #7 SRB holddown bolt did not eject properly and (2) both SRBs were lost due to malfunctions of the Recovery Subsystem. The FTPRs generated on these anomalies are presented in Figures 2.1.4-1 and 2.1.4-2.

Statement of problem:

SRB's were not recovered

Discussion:

Both SRB's failed to decelerate properly after separation of the frustrums from the boosters resulting in the loss/sinking of both SRB's.

Required date for resolution: STS-5 FRR

Personnel assigned: STS-4 Board of Investigation

Roger E. Mitchell for G. B. Hardy

Action Progress:

In accordance with the MSFC Contingency Plan, a Board of Investigation was appointed by the MSFC Director to conduct a complete investigation of the loss of the SRB's and to publish a comprehensive report of its findings:

The Board of Investigation has concluded its investigation and is in the process of compiling its report.

Effect on subsequent missions:

None expected for STS-5

Conclusions:

They will be published in the report of the Board of Investigation.

Corrective action:

Separation nuts will be replaced by non-explosive structural nuts for STS-5.

FIGURE 2.1.4-1 FLIGHT TEST PROBLEM REPORT - MSFC-1

FLIGHT TEST PROBLEM REPORT NO. MSFC-2 9/15/82

Statement of problem:

One SRB hold-down bolt did not eject properly at liftoff.

Discussion:

Hold-down bolt No. 7 on the LH SRB did not eject properly ar liftoff.

At STS-2 liftoff two (Nos. 6 and 8) of the eight hold-down bolts did not properly eject. Bolt tension preload method and procedures were revised to assure that correct preload was applied and maintained. The timing skew between the two detonations of the nut is suspected as the most likely cause for the bolt ejection problem after analysis of STS-4 liftoff experience.

Required date for resolution:
Not liftoff/flight critical

Personnel assigned: EP15/O. Harrison

Roger E. Mitchell for C. B. Hardy

Action Progress:

Approval has been given to conduct a timing-delay (time skew) firing test between detonators 1 and 2 on a hold-down nut. Eight nuts will be used in the test series. Tests are scheduled to start at KSC on September 16, 1982.

Effect on subsequent missions:

None expected

Conclusions:

None can be formulated until after analysis of KSC test results.

Corrective action:

Awaiting results of KSC test.

FIGURE 2.1.4-2 FLIGHT TEST PROBLEM REPORT - MSFC-2

2.2.0 SRB MASS PROPERTIES - Table 2.2.0-1 shows final mass properties for the left-hand (LH) and right-hand (RH) SRBs, respectively. These data are compared against preflight data at selected mission time points.

No weight changes were applied to the preflight prediction at the ignition time point. Differences noted at end of action time, separation and splashdown are attributed to the burn profile and to the probability that the nozzle exit cones were not jettisoned. Prior to the flight, an error was detected in the (RH) SRM center of gravity resulting in an aft cg movement of 1.7 inches at the separation time point.

The ignition and separation "X" center of gravity impacts are 0.00 inches and +0.36 inches (LH) and +0.11 inches and +1.68 inches (RH), respectively. The separation center of gravity is 59.18% (LH) and 59.31% (RH) of vehicle length. The mean liftoff inert weight and standard deviation of flight motors utilized thus far is 189,499 +/- 561 pounds. For the loaded condition, the mean weight is 1,297,339 +/- 1,089 pounds. At separation, the mean weight is 182,316 +/- 479 pounds. These data were derived from a sample of 8.

Table 2.2.0-2 provides a weight comparison between predicted and flight evaluation data.

TABLE 2.2.0-1 SRB MASS PROPERTIES COMPARISON

EVENT	STS-4A (LH) PREDICTED*	STS-4A (LH) FINAL	STS-4A (LH) DELTA	STS-4B (RH) PREDICTED*	STS-4B (RH) FINAL	STS-4B (RH) DELTA
IGNITION						
WEIGHT, POUNDS	1,298,213	1,298,213	0	1,299,253	1,299,253	0
"X" CG, INCHES	1168.77	1168.77	0	1168.82	1168.93	+0.11
EOAT						
WEIGHT, POUNDS	183,710	183,818	+108	183,404	183,175	+ 229
"X" CG, INCHES	1258.01	1257.46	-0.55	1258.53	1260.42	+1.89
SEPARATION						
WEIGHT, POUNDS	182,947	182,937	- 10	182,666	182,651	- 15
"X" CG, INCHES	1259.51	1259.15	-0.36	1259.67	1261.35	+1.68
SPLASHDOWN						
WEIGHT, POUNDS	167,936	169,889	+1,953.	167,603	169,569	+1,966.
"X" CG, INCHES	1317.43	1324.34	+6.91	1317.68	1326.92	+9.24

*REFERENCE MSFC MEMORANDUM EL43 (46-82) DATED APRIL 15, 1982.

TABLE 2.2.0-2 STS-4 WEIGHT COMPARISON

	WEIGHT (POUNDS)					
	STS-4A (LH)			STS-4B (RH)		
	PREDICTED	FLIGHT	DELTA	PREDICTED	FLIGHT	DELTA
SRB SUBSYSTEM	(41,123)	(41,123)	0	(41,330)	(41,330)	0
STRUCTURE	28,067			28,202		
RECOVERY	7,333			7,333		
THRUST VECTOR CONTROL	2,329			2,329		
SEPARATION	1,343			1,343		
ELECTRICAL/INSTRUMENTATION	1,901			1,973		
RANGE SAFETY	150			150		
SRM (INERT)	(149,116)	(149,116)	0	(148,630)	(148,629)	-1.0
STRUCTURE	125,353	125,347	-6.0	125,205	125,208	+3.0
INSULATION	18,465	18,473	+8.0	18,222	18,217	-5.0
LINER	1,353	1,354	+1.0	1,349	1,348	-1.0
INHIBITOR	1,933	1,938	+5.0	1,951	1,958	+7.0
IGNITION SYSTEM	488	482	-6.0	488	488	0
INSTRUMENTATION	287	288	+1.0	257	256	-1.0
EXTERNAL INSULATION	1,007	995	-12.0	932	918	-14.0
UNCONTROLLED INERT	230	239	+9.0	226	236	+10.0
PROPELLANT	(1,107,973)	(1,107,973)	0	(1,109,293)	(1,109,293)	0
USEABLE	(1,107,203)	(1,107,102)	(-101)	(1,108,546)	(1,108,784)	(-238)
TO LIFTOFF	562	571	+9.0	562	569	+7.0
LIFTOFF TO COAT	1,106,641	1,106,531	-110	1,107,984	1,108,215	+231
UNUSEABLE	(770)	(871)	(+110)	(747)	(509)	(-238)
COAT TO SEPARATION	758	717	-41	730	491	-239
UNEXPENDED	12	154	+142	17	18	+1.0
SLAG	615	615	0	615	615	0

2.3.0 SRM PROPULSION PERFORMANCE

2.3.1 SRM PROPULSION PERFORMANCE COMPARISONS

2.3.1.1 SRM PERFORMANCE COMPARISONS TO PREDICTED -- The SRMs for STS-4 are designated A13 and A14 for the left and right motors, respectively, as viewed from the aft end of the vehicle. All times shown in this section, unless noted otherwise, are referenced to the SRB ignition command time at 1982:178:14:59:59.793 (GMT).

All actual performance data were derived from the Orbiter Flight Instrumentation data base (12.5 sps). The SRB recorders which have high sample rates (320 sps) had not been recovered when this report was prepared. Ignition performance requiring the high sample rate is not shown and is noted N/A, meaning not available.

The STS-4 (A13/A14) thrust-time performance is compared to the predicted performance on Figures 2.3.1-1 and 2.3.1-2. These figures show the comparison for the steady state/tailoff traces for STS-4(A13) and STS-4(A14), respectively. The actual ignition transients are not available.

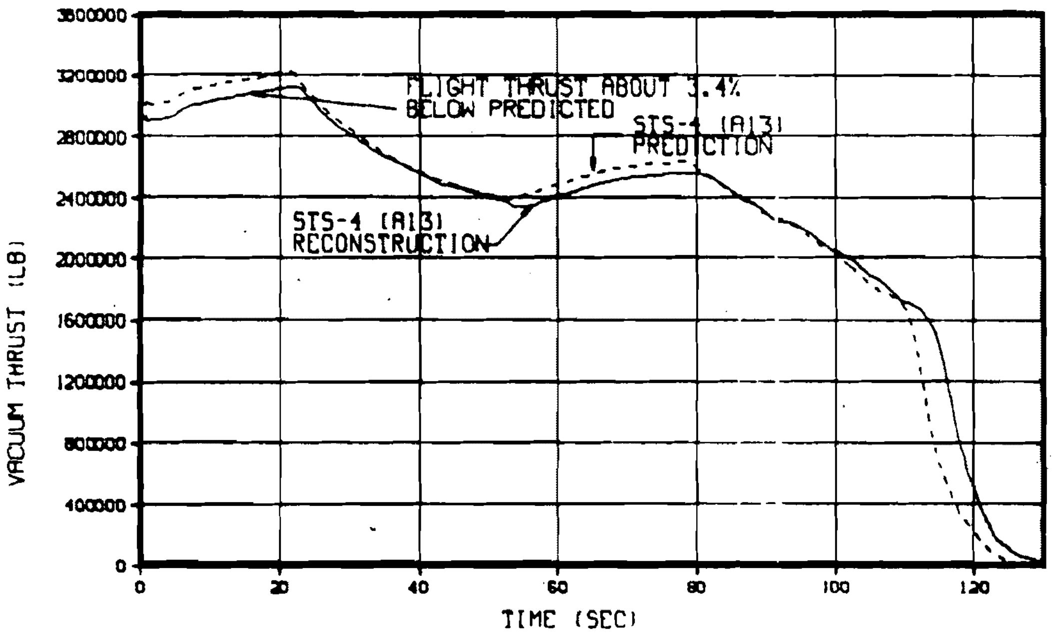


FIGURE 2.3.1-1 STEADY STATE-TAILOFF LH SRM VACUUM THRUST

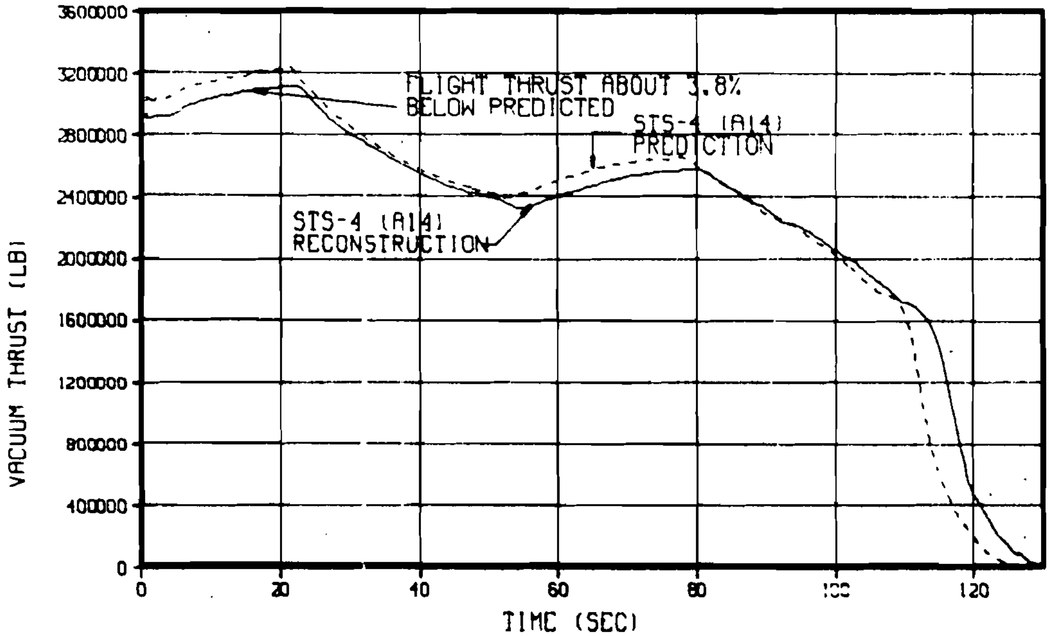


FIGURE 2.3.1-2 STEADY STATE-TAILOFF RH SRM VACUUM THRUST

The maximum percent differences during steady state operation between the predicted and reconstructed values of thrust plus the times of occurrence are shown on the following table.

STS-4(A13)		STS-4(A14)	
MAX DIFFERENCE*	TIME (SEC)	MAX DIFFERENCE*	TIME (SEC)
-3.6	3.0	-4.0	6.0
-3.4	21.0	-3.8	20.0
-3.1	61.5	-4.0	62.5
3.7	106.5	3.8	106.0

* % DIFFERENCE = ((RECONSTRUCTED - PREDICTED)/PREDICTED) X100

2.3.1.2 <u>SRM PREDICTED IMPULSE, ISP, BURN RATE COMPARISON</u> - The STS-4(A13/A14) reconstructed vacuum impulse performance is compared to the predicted performance on the following table.

IMPULSE GATES	PREDICTED	RECONSTRUCTED	DELTA(%)*
STS-4(A13)			
I20 (10**6 LB-SEC)	61.90	59.85	-3.31
I60 (10**6 LB-SEC)	169.90	165.00	-2.07
IAT (10**6 LB-SEC)	294.43	295.57	0.39
STS-4(A14)			
I20 (10**6 LB-SEC)	62.20	59.94	-3.63
I60 (10**6 LB-SEC)	169.64	165.28	-2.57
IAT (10**6 LB-SEC)	294.78	295.84	0.36

*DELTA = ((RECONSTRUCTED - PREDICTED)/PREDICTED) X100

The predicted and reconstructed (based on OFI data - 12.5 sps) vacuum specific impulses at action time are compared as follows:

	VACUUM ISP (SEC)		
	PREDICTED	RECONSTRUCTED**	DELTA*
STS-4(A13)	265.70	266.77	1.07
STS-4(A14)	265.70	266.70	1.00

*DELTA = RECONSTRUCTED - PREDICTED
**HISTORICALLY THE OFI DATA (12.5 SPS) EXCEEDS THE SRB DFI DATA (320 SPS) BY 0.23% (ABOUT 0.6 SEC.)

The predicted and reconstructed propellant burning rates are compared as follows:

	BURN RATE (IN/SEC)		
	PREDICTED	RECONSTRUCTED	DELTA(%)*
STS-4(A13)	.3708	.3642	-1.83
STS-4(A14)	.3712	.3638	-2.05

*DELTA = ((RECONSTRUCTED - PREDICTED)/PREDICTED) X100

2.3.1.3 SRM EVENT TIME COMPARISON TO PREDICTED - The actual STS-4(A13/A14) event times are compared to the predicted values on the following table.

	PREDICTED	ACTUAL	DELTA*
STS-4(A13)			
IGNITION INTERVAL (SEC)	0.226	N/A	N/A
WEB TIME (SEC)	110.6	114.2	3.6
TIME OF 50 PSIA CUE (SEC)	120.2	122.9	2.7
ACTION TIME (SEC)	122.4	126.1	3.7
STS-4(A14)			
IGNITION INTERVAL (SEC)	0.226	N/A	N/A
WEB TIME (SEC)	110.4	114.1	3.7
TIME OF 50 PSIA CUE (SEC)	119.9	123.9	4.0
ACTION TIME (SEC)	122.1	127.0	4.9

*DELTA = ACTUAL - PREDICTED

6.0 Second

The predicted and actual separation command times are compared on the following table. Separation is based upon the 50 psia cue from the last SRM plus 6.0 seconds plus a time interval between receipt and execution of the command to separate. No time delay is assumed in the prediction.

	SEPARATION COMMAND TIME (SEC)
PREDICTED	126.17
ACTUAL	129.98
ACTUAL - PREDICTED	3.81

2.3.1.4 SRM PMBT - The error in the preflight prediction of the propellant mean bulk temperature (PMBT) of the SRM contributes to the difference between the predicted and actual thrust levels and times. The preflight predicted PMBT is issued to JSC/RI at L-7 days and is based upon monitoring the SRM environment in the VAB and on the pad until L-10 days. The environment after L-10 days is forecast by the Atmospheric Sciences Division at MSFC. The postflight PMBT is determined by using measured environment data instead of the forecast. The preflight predicted PMBT and postflight calculated PMBT are compared as follows:

	PMBT (DEGREES F)		
	PREFLIGHT	POSTFLIGHT	DELTA*
STS-4(A13)	80.	78.	-2.
STS-4(A14)	80.	78.	-2.

*DELTA = POSTFLIGHT - PREFLIGHT

2.3.1.5 SRM TEMPERATURE PROFILE– The STS-4(A13/A14) segment temperature profiles at ignition are shown on the following table. The profile is shown for one segment and is representative of the temperature gradients throughout both motors. The angular locations are measured counterclockwise from the 0 degree reference (South) looking forward from the motor aft end.

SEGMENT DISTANCE (IN)**	TEMPERATURE (DEG F) 0*	45*	90*	135*	180*	225*	270*	315*
0	82.1	79.5	78.6	79.3	79.6	86.5	94.5	94.4
2.63	76.3	75.6	75.4	75.8	76.6	80.2	81.6	79.7
7.88	76.0	75.4	75.3	75.6	76.1	77.9	78.6	77.6
14.19	77.0	76.5	76.4	76.6	77.2	78.6	79.2	78.4
21.56	77.8	77.3	77.2	77.4	77.9	78.9	79.4	78.8
28.94	78.1	77.7	77.6	77.8	78.2	79.0	79.3	78.9
36.31	77.8	77.9	77.9	77.9	78.2	78.7	78.9	78.7

* DEGREES ROTATION
** MEASURED TO CENTER OF MOTOR FROM OUTSIDE OF CASE WALL.

2.3.2 SRM NOMINAL PERFORMANCE REQUIREMENTS

2.3.2.1 STS-4(A13/A14) THRUST-TIME COMPARISON TO REQUIREMENTS – The SRM performance limits are specified in JSC 07700, Volume X. The flight motor reconstructed thrust-time traces are normalized to a PMBT of 60 deg F before comparing the traces to the JSC 07700, Volume X performance limits. The limits are constructed by applying the web time average vacuum thrust, web time, and action time dispersions to the JSC 07700, Volume X nominal thrust-time trace. The STS-4(A13) and STS-4(A14) reconstructed thrust-time traces normalized to 60 deg F are compared to the Volume X limits on Figures 2.3.2-1 and 2.3.2-2, respectively.

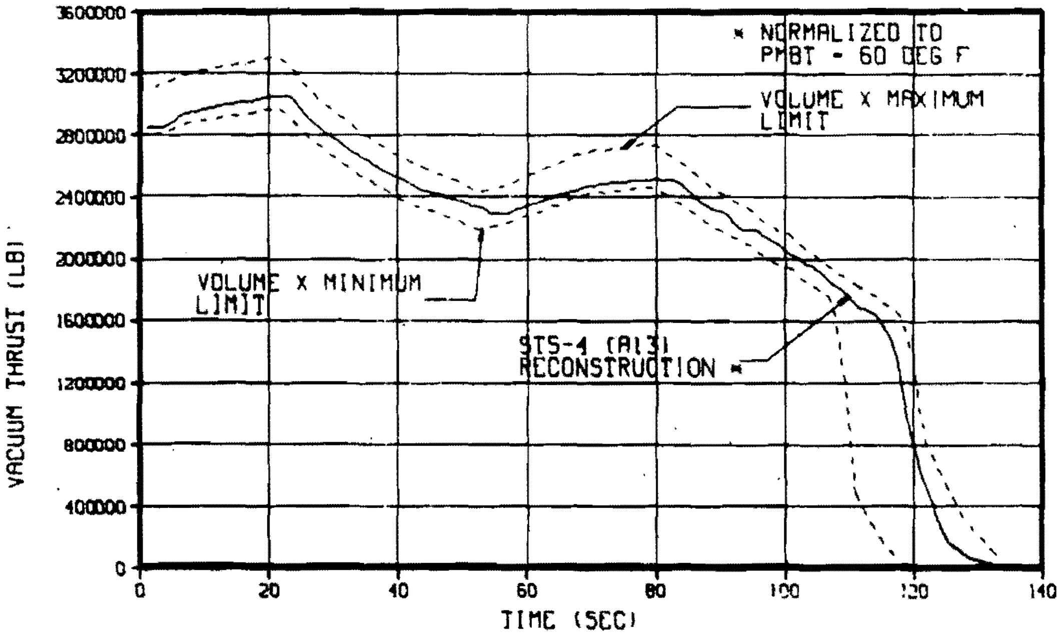


FIGURE 2.3.2-1 LH SRM RECONSTRUCTED VACUUM THRUST AT PMBT - 60 DEG F VS. VOLUME X THRUST-TIME LIMITS

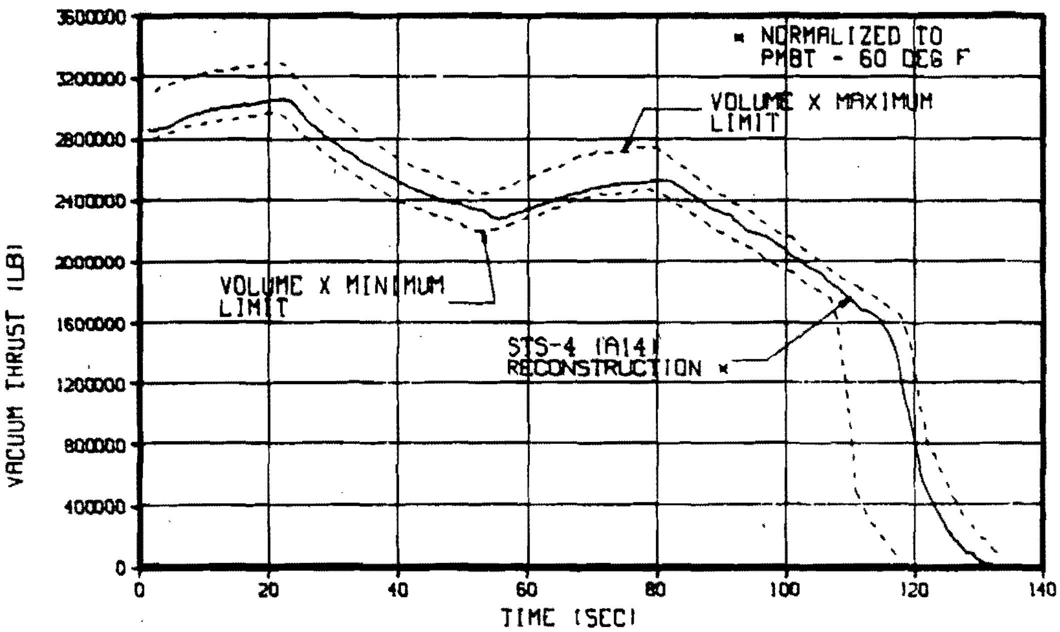


FIGURE 2.3.2-2 RH SRM RECONSTRUCTED VACUUM THRUST AT PMBT - 60 DEG F VS. VOLUME X THRUST-TIME LIMITS

2.3.2.2 SRM NOMINAL THRUST-TIME PERFORMANCE- The nominal SRM performance is defined as the average performance of the qualification static test and flight motor series at standard conditions. The standard conditions consist of the propellant burn rate of 0.368 ips at 625 psia and a PMBT of 60 Deg F. The flight motor reconstructed thrust-time traces are normalized to standard conditions and averaged with the QM static test data at standard conditions to form the SRM population nominal thrust-time trace. This nominal SRM performance will be continually updated during the Shuttle program. It is the current estimate of the total population nominal. The population nominal does not include STS-4 since the SRB DFI recorder data is not available. The SRM population nominal is compared to the JSC 07700, Volume X population performance requirements of +/-3% on Figure 2.3.2-3.

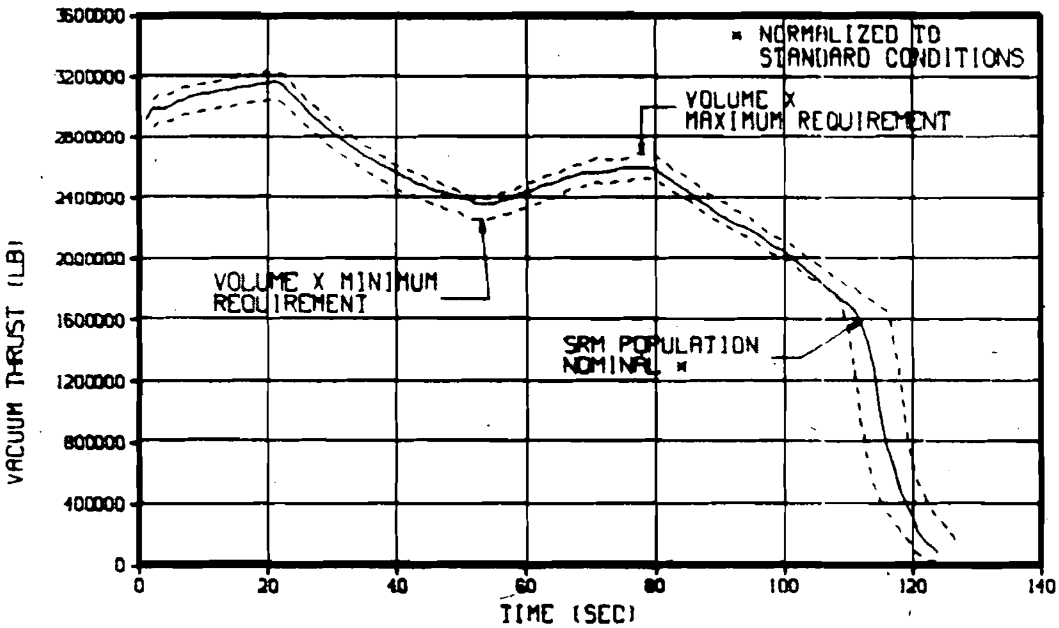


FIGURE 2.3.2-3 SRM NOMINAL VACUUM THRUST AT STANDARD CONDITIONS VS. VOLUME X THRUST-TIME REQUIREMENTS (+/- 3%)

The SRM population nominal at delivered conditions is the SRM population nominal at standard conditions coupled with the average target burn rate miss. The average burn rate miss is defined as the average of the differences in the target burn rate and the actual burn rate at PMBT=60 deg F for the QM/STS-1,2,3,4 static test and flight series. The average target burn rate miss is -.70%. The delivered SRM population nominal performance is compared to the JSC 07700, Volume X population performance requirements on Figure 2.3.2-4.

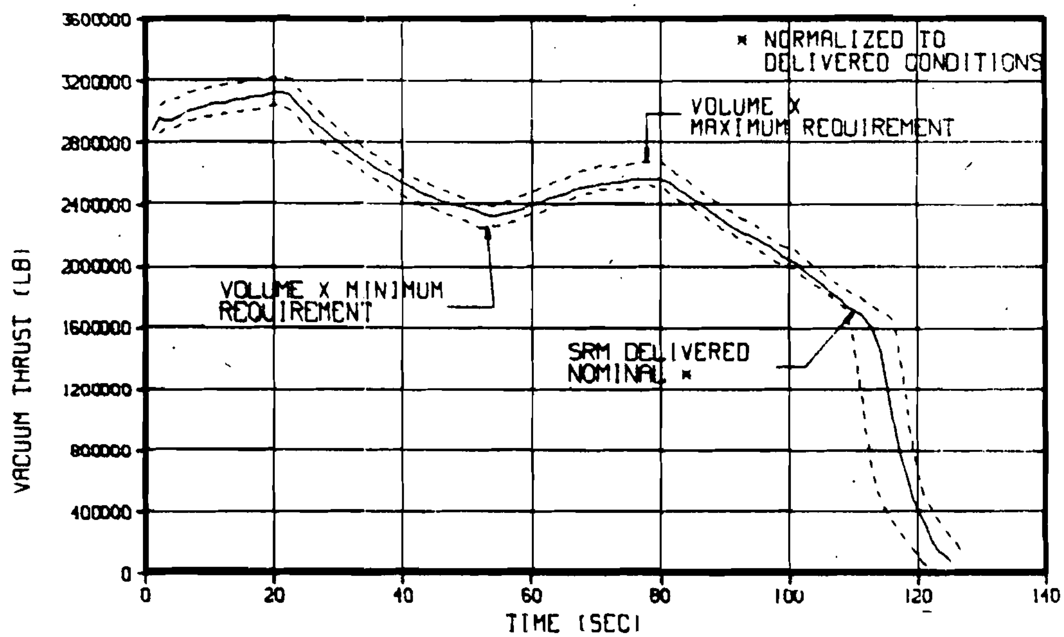


FIGURE 2.3.2-4 SRM DELIVERED NOMINAL VACUUM THRUST VS. VOLUME X THRUST-TIME REQUIREMENTS (+/- 3%)

The vacuum impulse at standard and delivered conditions at each of the gates is compared to the JSC 07700. Volume X requirements on the following table.

		SRM POPULATION	
IMPULSE	REQUIREMENT	NOMINAL*	DELIVERED NOMINAL**
120 (10**6 LB-SEC)	59.40 (MIN)	61.20	60.77
160 (10**6 LB-SEC)	165.50 170.46(+3%) 163.85(-1%)	167.62	166.45
IAT (10**6 LB-SEC)	291.20 (MIN)	294.43	294.43

*NORMALIZED TO STANDARD CONDITIONS
**NORMALIZED TO DELIVERED CONDITIONS - AVERAGE TARGET BURN RATE MISS (QM/STS-1,2,3,4)

2.3.3 SRM IGNITION PERFORMANCE

2.3.3.1 SRM IGNITION INTERVAL- The SRM ignition interval is required by the SRB CEI Specification to be between 170 and 340 milliseconds after ignition command to the NSIs in the S&A device. The ignition interval ends when the head end chamber pressure has increased to a value of 563.5 psia. The ignition intervals measured from the STS-4(A13) and STS-4(A14) motors are compared with the predicted intervals as follows on the following table.

	IGNITION INTERVAL (MS)		
	PREDICTED	MEASURED	DELTA*
STS-4(A13)	226	N/A	N/A
STS-4(A14)	226	N/A	N/A

*DELTA = MEASURED - PREDICTED

2.3.3.2 SRM IGNITION PRESSURE RISE RATE - The maximum rate of head end chamber pressure buildup during the ignition transient is required to be less than 109 psi for any 10 millisecond interval. The measured maximum ignition pressure rise rates for the STS-4(A13) and STS-4(A14) motors are compared with the predicted rise rates as follows:

	MAXIMUM IGNITION PRESSURE RISE RATE (PSI/10 MS)		
	PREDICTED	MEASURED	DELTA*
STS-4(A13)	91.0	N/A	N/A
STS-4(A14)	91.0	N/A	N/A

*DELTA - MEASURED - PREDICTED

2.3.4 SRB SEPARATION DELAY AND CUEING PRESSURE

2.3.4.1 SRB SEPARATION CUEING PRESSURE- SRB separation command was set to occur at 6 seconds after the SRM head end chamber pressure has decayed to 50 psia in both the STS-4(A13) and STS-4(A14) motors. The 50 psia cue time is defined as the time when the head end chamber pressure has decayed to 50 psia. The actual separation command time based upon this cue is 3.81

2.3.4.2 SRB PRE-SEPARATION THRUST-TIME HISTORY - The time delay for SRB separation command is fixed to allow the SRM thrust to decay to a value less than or equal to 60,000 pounds. The nominal and 3-sigma maximum SRM tailoff thrust-time history after the SRB head end chamber pressure has decayed to 50 psia has been derived based upon the STS-1, 2 and 3 flights. The reconstructed vacuum thrust for the STS-4(A13) and STS-4(A14) motors is compared to the nominal and 3-sigma maximum tailoff on Figure 2.3.4-1.

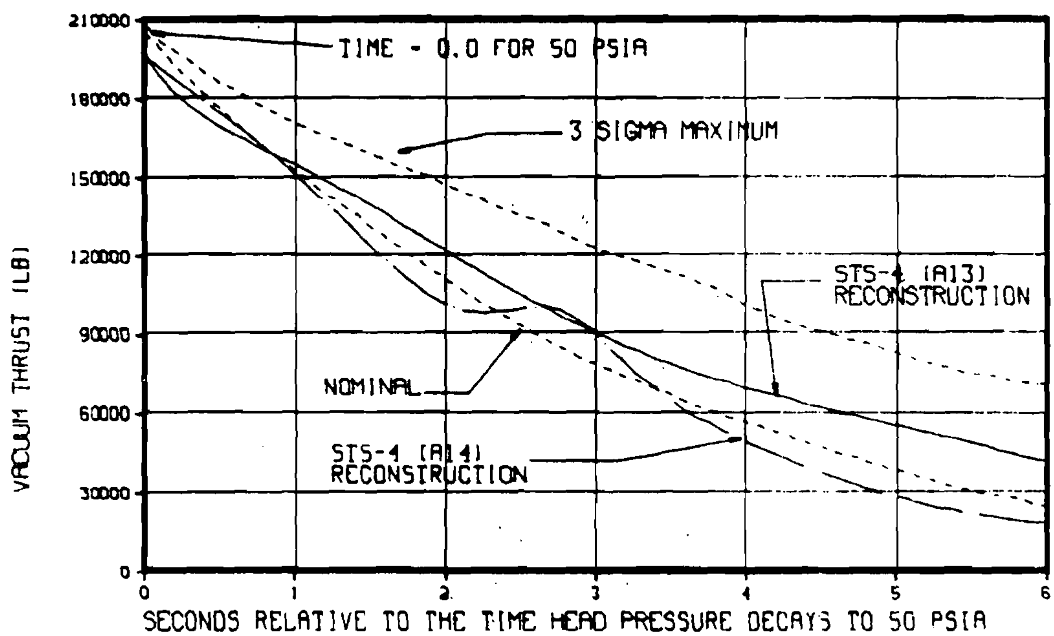


FIGURE 2.3.4-1 LH/RH SRM RECONSTRUCTED VACUUM THRUST-TIME HISTORIES VS. NOMINAL AND 3-SIGMA MAX TAILOFF

JSC 07700 Volume X specifies that the nominal decay time for motor head end pressure to decrease from 50 psia to a pressure corresponding to 60K pounds thrust is 2.4 seconds. A 3-sigma variation of this decay time is +/- 1.16 seconds. The transducer error for 50 psia is +/- 15 psia. The time variation associated with this error is 1.13 seconds. This variation and the above 3-sigma variation shall be root-sum-squared to + 1.62 seconds and added to the nominal decay time of 2.4 seconds for a maximum decay time of 4.0 seconds based upon cueing pressure. The decay time intervals for STS-4(A13) and STS-4(A14) are measured from the time the motor head end chamber pressure has decayed to 65 psia to the time corresponding to 60,000 pounds of thrust. The measured decay times are compared to the predicted decay times as follows:

	DECAY TIME (SEC)	
	STS-4(A13)	STS-4(A14)
PREDICTED	4.62	4.51
MEASURED	5.30	4.65
DELTA*	0.68	0.14

*DELTA = MEASURED - PREDICTED

The variation of the STS-4(A13) and STS-4(A14) measured decay time intervals with the average decay time is shown on the following table. The decay time is the time from 65 psia of chamber pressure to 60,000 pounds of thrust. The average decay time is based upon the average of the DM/QM/STS-1,2,3 static test and flight series.

	AVERAGE DECAY TIME (SEC)	DECAY TIME (SEC)	VARIATION FROM AVERAGE (SEC)
STS-4(A13)	4.73	5.30	0.57
STS-4(A14)	4.73	4.65	-0.08

2.3.4.3 STS-4 SRB SEPARATION COMMAND TIME DELAY - The STS-4 SRB separation command time delay of 6 seconds was selected to insure that the SRBs do not separate from the Shuttle vehicle before the SRM thrust decays below 60,000 pounds. This time delay was statistically determined from the DM/QM/STS-1, 2, 3 static test and flight series. The SRM separation time delay statistically based upon the DM/QM static test and flight motor series (STS 1, 2, 3) for STS-5 is 6.0 seconds.

2.3.5 MATCHED PAIR THRUST DIFFERENTIAL

2.3.5.1 MEASURED IGNITION THRUST IMBALANCE - The maximum thrust imbalance between two SRMs on the Shuttle vehicle for the first second of operation results from the sum of the difference in thrust-time profiles and the difference caused by a difference in the time of SRM ignition. This maximum thrust imbalance is defined by the AFSIG as +/-427,000 pounds over the time span from first ignition to 0.4 seconds. The comparison of reconstructed sea level thrust from ignition through 1.0 second between the STS-4(A13) and STS-4(A14) motors is not shown for STS-4 as the ignition transients are not available.

2.3.5.2 TIME DELAY BETWEEN SRM IGNITION - The time delay between the ignition of the LH and RH SRM is due to the avionics response to start command. The ignition time delay for STS-4 is not available.

2.3.5.3 NORMALIZED IGNITION THRUST IMBALANCE - The maximum thrust imbalance between two SRMs on the Shuttle vehicle defined in the SRB CEI Specification for the first second of operation assumes no time delay between the ignition of the LH and RH motors. On STS-4, no time delay is available. The difference in reconstructed thrust between the STS-4(A13) and the STS-4(A14) motors compared to the SRB CEI Specification ignition thrust imbalance profile is not shown. The ignition transients are not available.

2.3.5.4 STEADY STATE THRUST IMBALANCE - The maximum SRM steady state thrust imbalance for a matched pair of SRMs is defined by the SRB CEI Specification as 85,000 pounds beginning at 1.0 second and ending at 4.5 seconds before the earliest motor web time. The steady state thrust imbalance includes a transition during the 4.5 second time interval to the tailoff imbalance requirement by increasing linearly from 85,000 pounds to 268,000 pounds. The instantaneous thrust imbalance between STS-4(A13) and STS-4(A14) during steady state operation is compared to the SRB CEI Specification requirement on Figure 2.3.5-1.

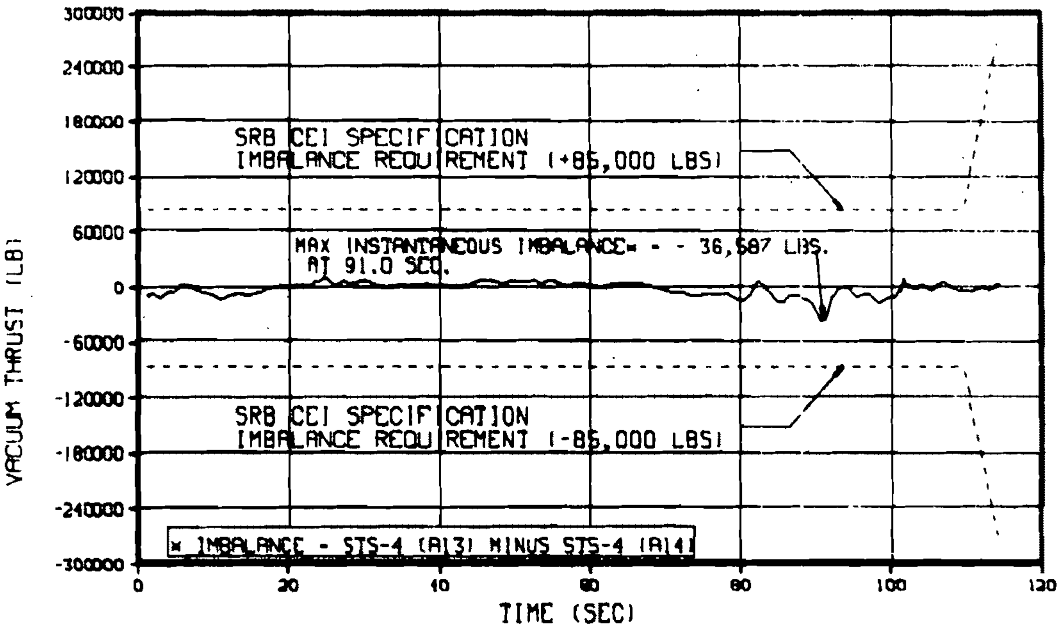


FIGURE 2.3.5-1 LH/RH INSTANTANEOUS STEADY STATE THRUST IMBALANCE VS. SRB CEI IMBALANCE REQUIREMENT

The thrust imbalance between STS-4(A13) and STS-4(A14) during steady state operation is the maximum difference between the reconstructed vacuum thrusts averaged over any four-second time span within the steady state interval. The steady state thrust imbalance over all 4 second spans between STS-4(A13) and STS-4(A14) is compared to the SRB CEI Specification requirement on Figure 2.3.5-2.

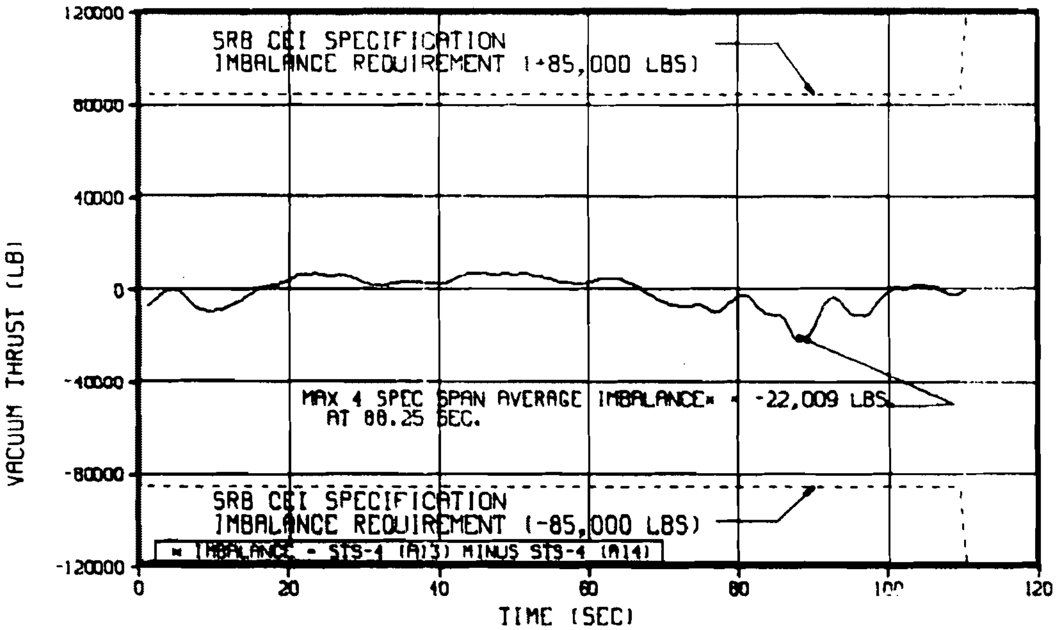


FIGURE 2.3.5-2 LH/RH SRM STEADY STATE 4-SECOND SPAN AVERAGE THRUST IMBALANCE VS. SRB CEI IMBALANCE REQUIREMENT

2.3.5.5 **<u>TAILOFF THRUST IMBALANCE</u>** **- The tailoff thrust imbalance between STS-4(A13) and STS-4(A14) is compared to the SRB CEI Specification requirement on Figure 2.3.5-3. The SRM tailoff imbalance time interval is defined in the SRB CEI Specification as beginning at the first motor web time and ending at the last motor action time.**

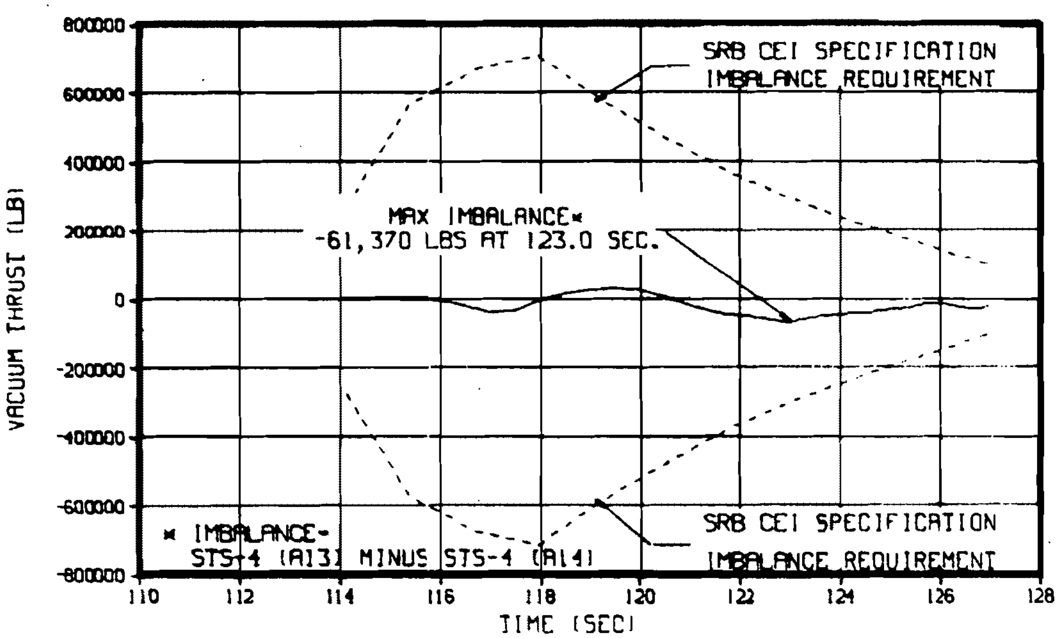


FIGURE 2.3.5-3 LH/RH SRM TAILOFF THRUST IMBALANCE VS. SRB CEI REQUIREMENT

The impulse during the tailoff time interval is to be less than or equal to 4,500,000 lb-sec. The impulse during tailoff is compared to the predicted impulse and the maximum requirement on the following table:

	TAILOFF IMBALANCE IMPULSE (10**6 Lb-sec)
MAXIMUM REQUIREMENT	4.500
PREDICTED	0.593
ACTUAL	0.200
DELTA*	-0.393

*DELTA - ACTUAL - PREDICTED

2.3.6 PERFORMANCE TOLERANCES

2.3.6.1 TOTAL POPULATION VARIATION - The parameter variations of the total population of SRMs about a nominal value are constrained by the requirements defined in the SRB CEI Specification. The nominal SRM performance is defined as the average performance of the QM static test and flight motor series at standard conditions. This nominal SRM performance will be continually updated with DFI data during the Shuttle program. It will not be updated for STS-4. It is the current estimate of the total population nominal. This performance is defined using the propellant burning rate of 0.368 in/sec at 625 psia and PMBT of 60 deg F. A comparison of the STS-4(A13/A14) calculated and reconstructed parameters at PMBT of 60 deg F with respect to the nominal values and the SRB CEI Specification maximum 3-sigma requirements is shown on the following table:

PARAMETER	SRB CEI (+ OR -) MAX 3-SIGMA VARIATION (%)	NOMINAL* VALUE	STS-4 (A13) (60 DEG F)	STS-4 (A13)** VARIATION (%)	STS-4 (A14) (60 DEG F)	STS-4 (A14)** VARIATION (%)
WEB TIME	5.0	111.98 SEC	116.19 SEC	3.8	116.04 SEC	3.6
ACTION TIME	6.5	123.40 SEC	128.08 SEC	3.8	128.98 SEC	4.5
WEB TIME AVG PRESSURE	5.3	648.4 PSIA	626.2 PSIA	-3.4	626.6 PSIA	-3.4
MAX HEAD END PRESSURE	6.5	863.0 PSIA	832.1 PSIA	-3.6	833.6 PSIA	-3.4
MAX SEA LEVEL THRUST	6.2	2,943,000 LB	2,824,000 LB	-4.1	2,820,000 LB	-4.2
WEB TIME AVG VAC THRUST	5.3	2,562,000 LB	2,479,000 LB	-3.2	2,481,000 LB	-3.2
VAC DEL SPECIFIC IMPULSE ***	0.7	265.84 SEC	266.53 SEC	0.26	266.45 SEC	0.23
WEB TIME VAC TOTAL IMP	1.0	286.87 MLB-SEC	288.00 MLB-SEC	0.39	287.87 MLB-SEC	0.35
ACTION TIME VAC TOTAL IMPULSE	1.0	294.27 MLB-SEC	295.10 MLB-SEC	0.28	295.46 MLB-SEC	0.40

* QM STATIC TEST/STS-1,2,3 AVERAGE AT STANDARD CONDITIONS
** VARIATION = ((STS-4(A13/14) - NOMINAL)/NOMINAL) X 100
*** BASED UPON OPERATIONAL PROPELLANT LOADING OF 1,107,880 POUNDS.

2.3.6.2 MATCHED PAIR SRM VARIATIONS- The parameter variations between the SRMs in a matched pair are constrained by requirements defined in the SRB CEI specification. The variations between the matched pair of SRMs shall be calculated using average measured values. The differences between the STS-4(A13) and STS-4(A14) calculated and reconstructed parameters are compared with the SRB CEI Specification requirements between matched pairs on the following table:

PARAMETER	SRB CEI MATCHED PAIR REQUIREMENTS (%)	STS-4(A13/A14) DIFFERENCE*	STS-4(A13/A14) VARIATION(%)**
WEB TIME	2.0	0.15 SEC	0.13
ACTION TIME	3.0	-0.94 SEC	-0.74
WEB TIME AVG PRESSURE	2.0	-0.4 PSIA	-0.06
WEB TIME AVG VAC THRUST	2.0	-2,055 LB	-0.08
VAC DEL SPECIFIC IMPULSE	1.0	0.07 SEC	0.03
WEB TIME VAC TOTAL IMPULSE	1.4	0.14 MLB-SEC	0.05
ACTION TIME VAC TOTAL IMPULSE	1.4	-0.36 MLB-SEC	-0.12

*DIFFERENCE = STS-4(A13) - STS-4(A14)
**VARIATION BASED UPON AVERAGE VALUE OF STS-4(A13/A14)

2.4.0 THRUST VECTOR CONTROL SYSTEM

2.4.1 SRB TVC SERVOACTUATOR PERFORMANCE - During prelaunch and ascent flight, all actuators performed as expected with respect to positioning accuracy, rates and redundant operation. In general, performance was similar to that exhibited by the STS-1 through STS-3 flight actuators, with no anomalies. Figures 2.4.1-1 through 2.4.1-4 show the measured actuator parameters for prelaunch and ascent flight. Shown for each actuator are the following: command (degrees), position (inches), secondary differential pressures for channels A, B, C and D (psid) and system supply pressure (psia). Actuator load data (actuator differential pressure and force) were lost on the DFI Recorders. Also lost were the actuators secondary position measurements intended for splashdown data.

2.4.1.1 SYSTEM DESCRIPTION - The TVC servoactuator is a four channel electrohydraulic proportional control device, receiving input commands in milliamps and outputting linear actuator piston position in inches. The SRB nozzle is then vectored in accordance with the nozzle pivot point and the actuator attaching geometry. The unlimited stroke capability of the actuator is +/- 6.4 inches (approximately +/- 6 degrees).

The actuator basically consists of the following subassemblies and components:

- Four servovalves (each consisting of conventional torque motor/ nozzle - flapper first stage with second stage spool)
- Four solenoid bypass valves
- Power valve
- Main actuator piston
- Prefiltration and supply source selector valve
- Hydraulic lock and manual bypass valve
- Four dynamic pressure feedback modules
- Mechanical piston position feedback mechanism
- Transient load relief mechanism
- Four servovalve differential pressure transducers
- Dual piston position transducers
- Actuator differential pressure transducer
- Actuator force measurement
- Primary pressure OK switch

Identical current commands to the torque motors create secondary differential pressure outputs from each servovalve. These are summed on the simplex power valve spool to divert flow into either side of the main actuator piston, effecting an extend or retract piston output motion. Position of the main piston is mechanically fed back to the torque motors to stop actuator travel when the commanded position is reached.

Servovalve secondary differential pressures are transmitted to the Ascent Thrust Vector Controller (ATVC) for redundancy management. The ATVC will activate a solenoid bypass valve, thus isolating an offending servovalve, should that valve's secondary differential pressure output exceed 2000 +/-200 psid for 120 milliseconds.

Pressure source redundancy is achieved with the supply pressure source selector valve which receives a primary and secondary supply pressure (each nominally at 3000 to 3250 psia) from the "A" and "B" APUs. A primary supply pressure falling into the 1900-2200 psia range causes switching to the secondary source. A primary pressure OK indicator switch signals the source status as "on" for the primary mode and "off" for the secondary mode.

Polarities for the telemetered actuator parameters are as follows:

Position:	"+" indicates actuator extend
Command:	"+" indicates actuator extend for LH Rock & RH Tilt
	"-" indicates actuator extend for LH Tilt & RH Rock
Secondary differential pressure:	"+" extends actuator
Actuator differential pressure:	"+" indicates actuator extend or compressive load
Actuator force:	"+" indicates compressive load

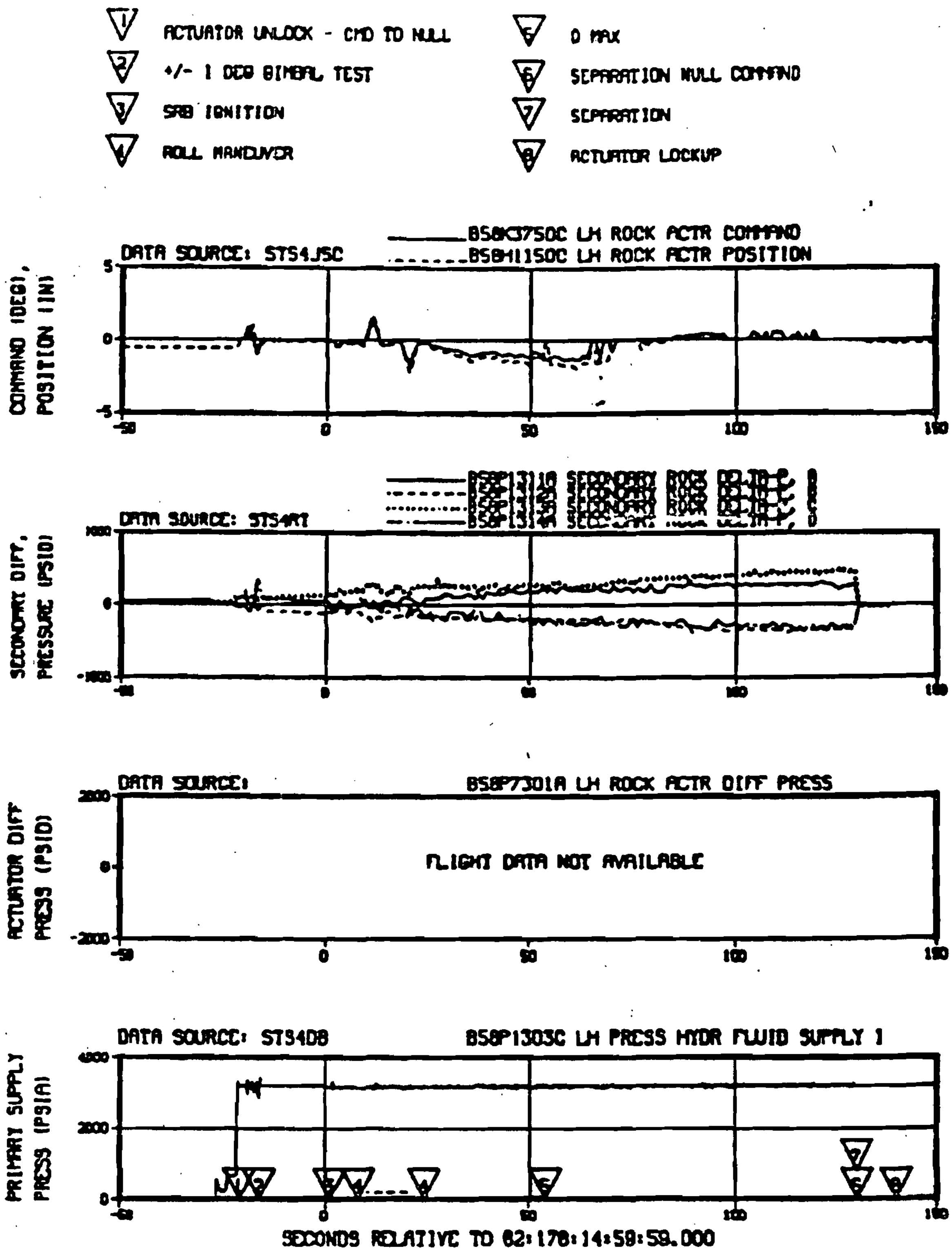


FIGURE 2.4.1-1 LH ROCK ACTUATOR PARAMETERS

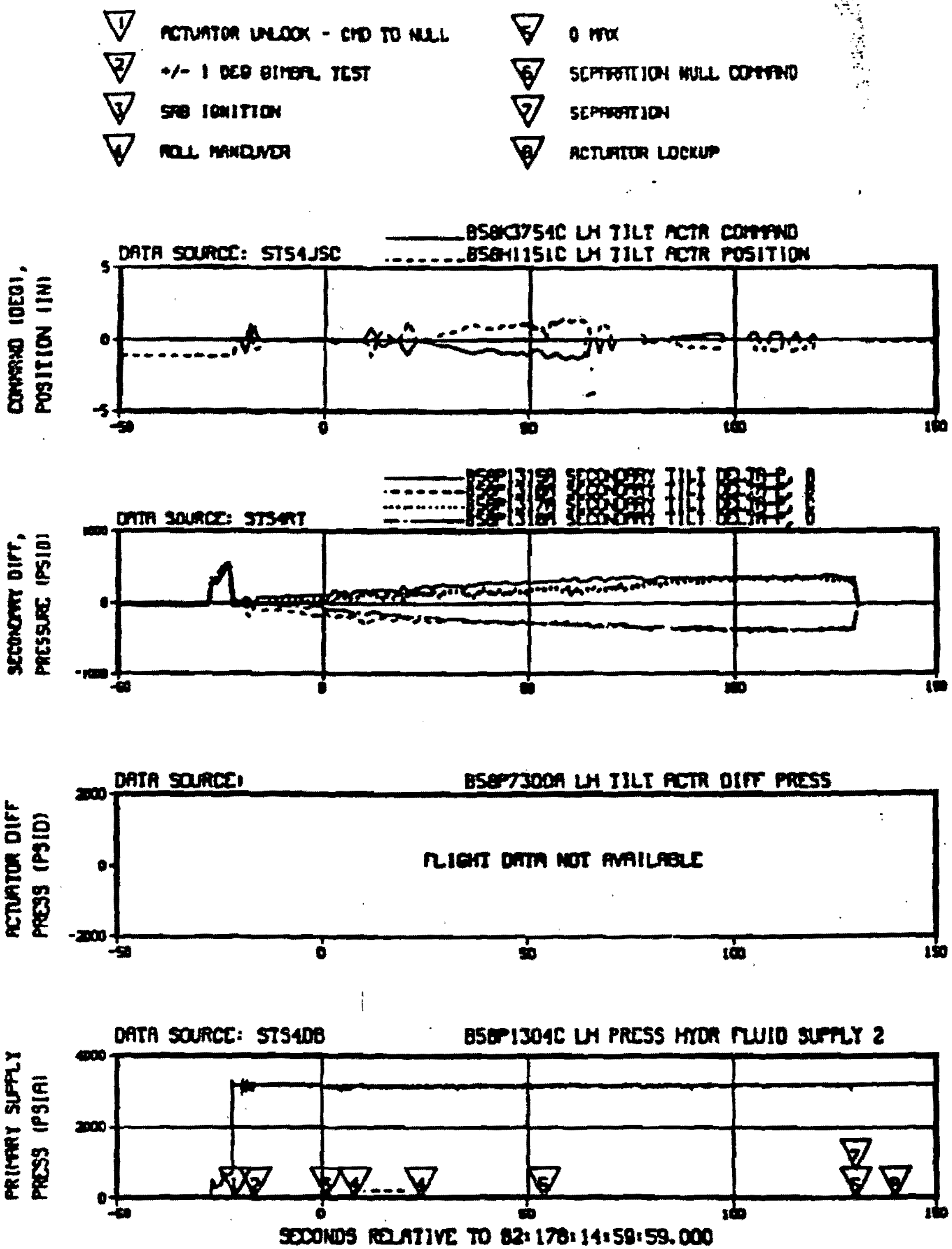


FIGURE 2.4.1-2 LH TILT ACTUATOR PARAMETERS

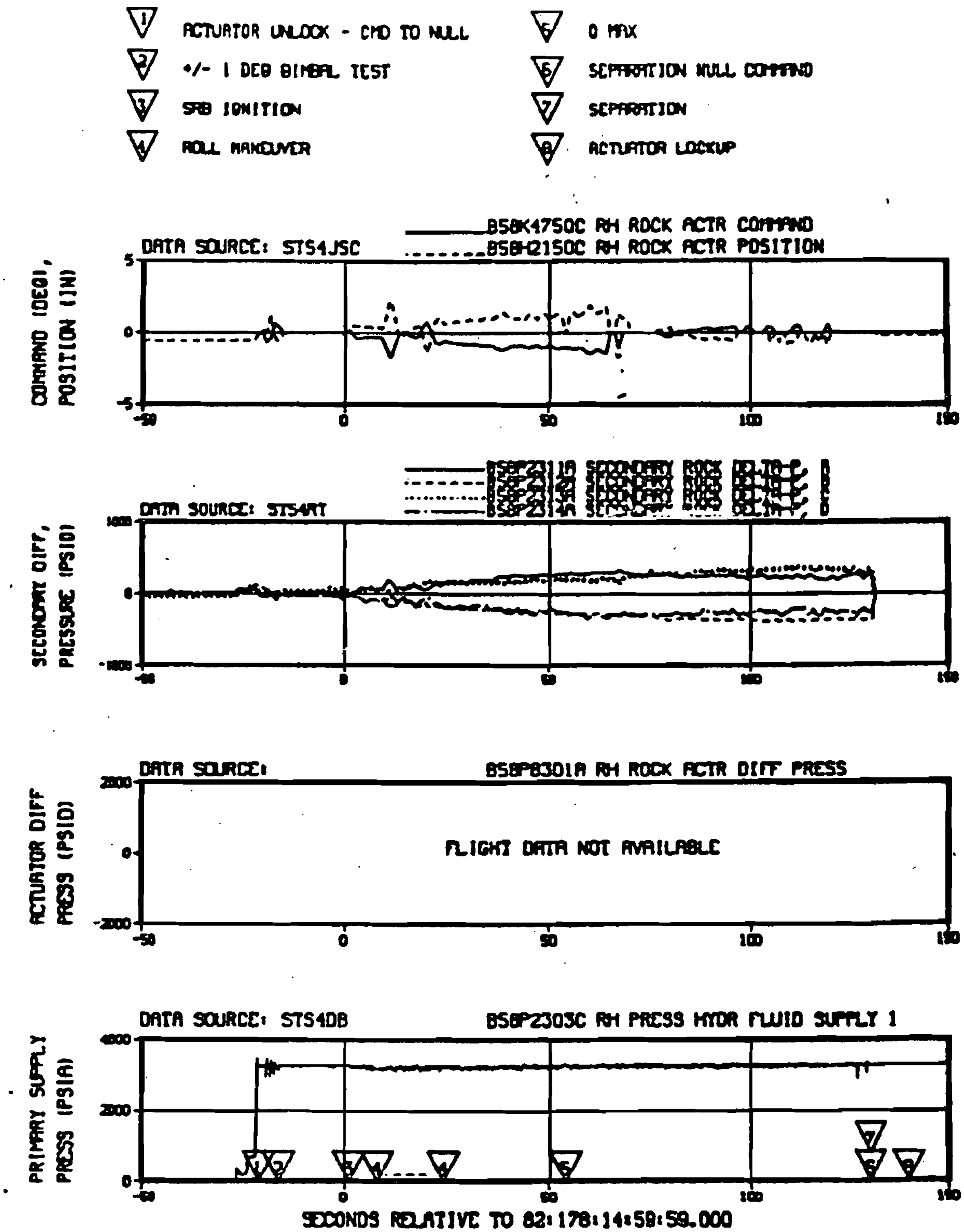


FIGURE 2.4.1-3 RH ROCK ACTUATOR PARAMETERS

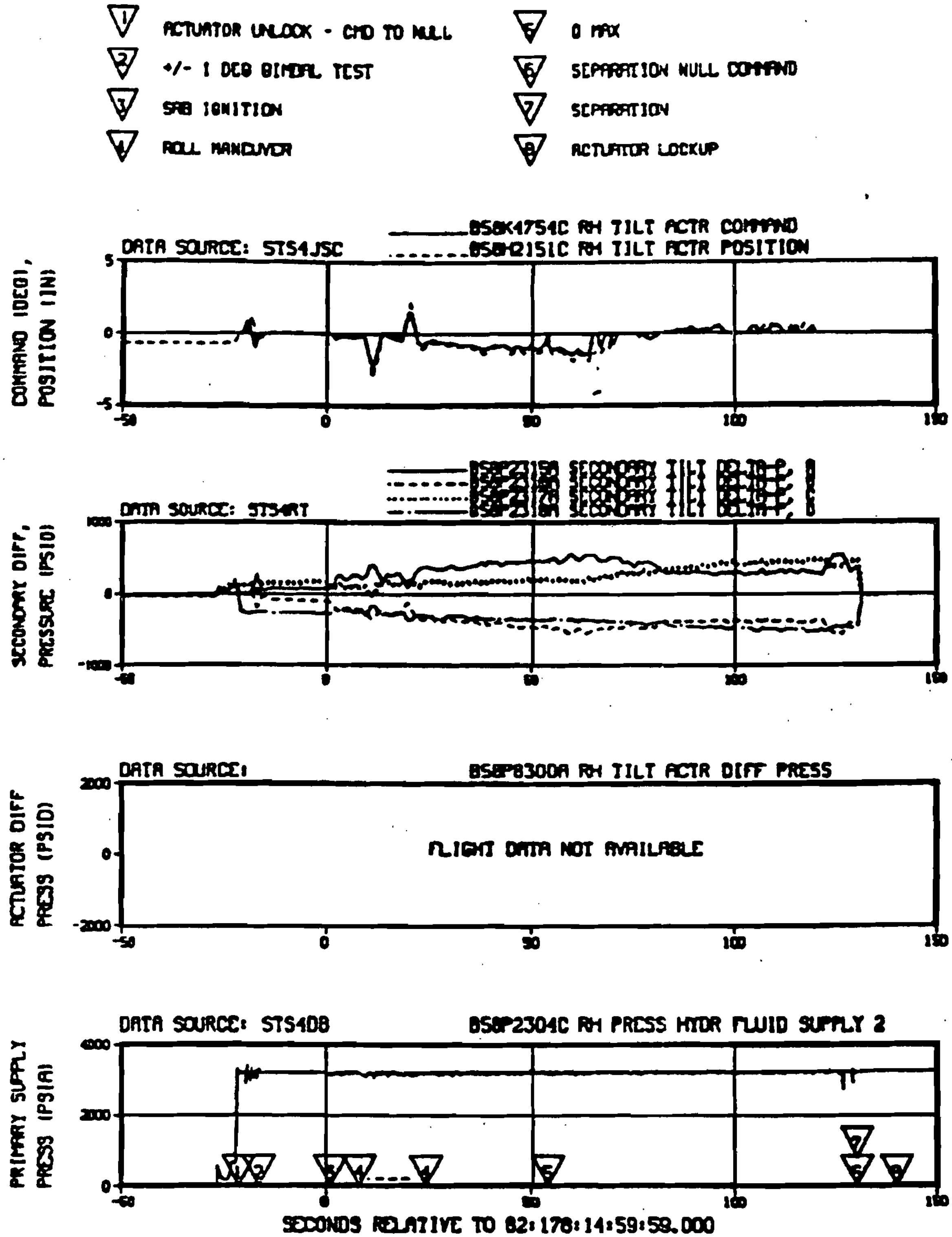


FIGURE 2.4.1-4 RH TILT ACTUATOR PARAMETERS

2.4.1.2 LAUNCH COUNTDOWN REDLINES - The redlines imposed during launch countdown were met with ample margins. Redline parameters consisted of 16 secondary differential pressures, 16 actuator channel failure indications and 4 actuator positions. The redline requirement is +/-1 deg +/- 0.5 during the gimbal test and 0 deg +/- 0.4 during the null requirement. The secondary differential pressures are required to be 0 psid +/- 990 from gimbal test completion to "go for SSME start." All channel bypass commands were "off" as required from SRB gimbal test start to "go for SSME start."

2.4.1.3 ACTUATOR AND NOZZLE POSITIONS - These data are summarized in Tables 2.4.1-1 and 2.4.1-2. Tabulated are the maximum excursions for specific events during prelaunch and ascent flight. The maximum excursion occurred on the right tilt actuator during initiation of the roll maneuver Also tabulated are the actuator null positions and associated angles during prelaunch and just prior to separation.

TABLE 2.4.1-1 SRB TVC ACTUATOR MAXIMUM POSITIONS

	LEFT SRB		RIGHT SRB	
	ROCK	TILT	ROCK	TILT
PRELAUNCH				
INITIAL NULL OFFSET	-0.59	-1.13	-0.54	-0.64
+ 1 DEG GIMBAL TEST	1.25	1.22	1.33	1.40
- 1 DEG GIMBAL TEST	-1.33	-1.32	-1.24	-1.20
NULL	-0.05	-0.05	.05	0.10
SRM IGNITION	-0.5	-0.5	0.6	-0.4
ROLL MANEUVER				
INITIATION	2.0	-1.3	2.4	-3.2
CORRECTION	-2.2	1.3	-1.4	2.2
Q MAX	-1.9	1.5	1.8	-1.9
SEPARATION NULL	-0.18	-0.2	-0.15	-0.03

NOTE: POSITIONS IN INCHES ACTUATOR PISTON TRAVEL FROM NULL POSITION

TABLE 2.4.1-2 SRB NOZZLE VECTOR POSITIONS

	LEFT SRB		RIGHT SRB	
	ROCK	TILT	ROCK	TILT
PRELAUNCH				
INITIAL NULL OFFSET	.00	-.31	.12	-.03
+ 1 DEG GIMBAL TEST	1.42	1.51	1.58	1.54
- 1 DEG GIMBAL TEST	-.58	-.46	-.44	-.47
NULL	.42	.52	.55	.52
SRM IGNITION	-.50	-.25	.35	-.25
ROLL MANEUVER				
INITIATION	1.39	-1.20	1.65	-2.59
CORRECTION	-1.90	.85	-1.23	1.52
Q MAX	-1.45	1.20	1.44	-1.45
SEPARATION NULL	0.35	0.42	.45	.50

NOTE: POSITIONS IN DEGREES OF VECTOR ANGLE FORM NULL POSITION

2.4.1.4 ACTUATOR POSITIONING ACCURACY - Actuator positions closely followed commands during flight. These data are summarized in Table 2.4.1-3. In general, the larger errors occurred at separation null. This was caused by temperature sensitivity of the servovalve configuration. This sensitivity induced a drift to the retract direction as hydraulic fluid temperature increased. This trend is consistent with STS-1 through STS-3 flights.

TABLE 2.4.1-3 SRB TVC ACTUATOR POSITIONING ERRORS

	LEFT SRB ROCK	LEFT SRB TILT	RIGHT SRB ROCK	RIGHT SRB TILT
PRELAUNCH				
+ 1 DEG GIMBAL TEST	0.05	.02	-0.01	-0.12
- 1 DEG GIMBAL TEST	.01	.01	-0.01	-0.06
NULL	.04	.04	-0.04	-0.08
SRM IGNITION	0.05	0	-0.03	-0.08
ROLL MANEUVER				
INITIATION	0.03	0.04	0.05	-0.08
CORRECTION	0.10	0.06	0.05	-0.09
Q MAX	0.13	0.08	0.07	0.02
SEPARATION NULL	0.14	0.16	0.12	0.02
NET NULL DRIFT	-0.10	-0.12	-0.16	-0.10

NOTE: POSITION ERRORS IN DEGREES
ERROR - ACTUATOR COMMAND (DEG) -0.8 * ACTUATOR POSITION (IN)

2.4.1.5 <u>ACTUATOR RATES</u> - Table 2.4.1-4 summarizes the actuator rate history. Rates were highest during prelaunch when actuators were initially unlocked by system pressure application. The offset positions coupled with zero command caused these rates to be high. During the ascent flight phase, significant rates were encountered during guidance release after ignition, roll maneuver and actuator null prior to separation.

TABLE 2.4.1-4 SRB TVC ACTUATOR MAXIMUM RATES

	LEFT SRB ROCK	LEFT SRB TILT	RIGHT SRB ROCK	RIGHT SRB TILT
PRELAUNCH				
ACTUATOR NULL	4.0	6.7	4.6	4.7
GIMBAL TEST	4.5	4.6	4.3	4.4
SRM IGNITION	2.4	2.3	2.8	2.6
ROLL MANEUVER				
INITIATION	1.7	1.0	2.3	2.9
CORRECTION	1.5	0.9	1.4	2.0
Q MAX	0.3	0.2	0.5	0.3
THRUST TAILOFF	0.4	0.3	0.5	0.8
SEPARATION NULL	1.6	2.2	3.0	4.1

NOTE: RATES IN DEGREES/SEC (SCALE FACTOR - 0.8 DEG/IN)

2.4.1.6 SECONDARY DIFFERENTIAL PRESSURES - The secondary differential pressures are measured from channels A, B, C, D of each actuator. Pressures were within 0 +/- 250 psig during prelaunch and drifted to steady state values of +/-500 psig at separation. This drift was caused by the servovalves sensitivity to temperature and is consistent with results of previous flights.

2.4.1.7 DUTY CYCLE - The total accrued angle for all actuators during prelaunch and ascent flight was 145 degrees. The allotment to the left rock, left tilt, right rock and right tilt actuators are respectively 32, 32, 39 and 42 degrees. Total number of degree-seconds required from the actuators were 83, 56, 86, and 82, respectively.

2.4.2 HYDRAULIC POWER SUBSYSTEM PERFORMANCE - On Tables 2.4.2-1 and 2.4.2-2 are summarized the critical flight measurements and prelaunch event times for this flight. Several differences were noted between this and previous flights. First, this is the first flight using a piston accumulator, which is precharged with 98 +/- 1 cu. in. of GN2 at 2000 +/- 50 psia. The accumulators are physically located near each actuator and are shown schematically on Figure 2.4.2-1. The hydraulic pressure trace (typical of all) shown on Figure 2.4.2-2 indicates that pressure fluctuations were significantly decreased when the accumulator was employed. This verification can be made by comparing Figures 2.4.2-2 with Figure 2.4.2-3. Unfortunately a more detailed comparison cannot be made since the high sample DFI measurements are not currently available. Figure 2.4.2-2 indicates a much greater drop in the reservoir level than has been previously seen. The 3.2% additional drop was due to charging the accumulator during pressure buildup to 3200 psi in the system. If the 3.2% is subtracted from the tabulated values (pre-start and post start) the level decrease will be in very close agreement with STS-1, 2 and 3 data. The second discrepancy noted concerned the right hand, B system FSM pressure. For some time prior to the terminal countdown it had been noted that the FSM pressure had been decaying at a constant slow rate, approximately 1 to 1.5 psi per day after correcting for temperature. This pressure was carefully monitored during the prelaunch period and no noticeable rate increase was noted. The other 3 FSM pressures were at least 20 psi higher when the final countdown was initiated. The 350 psia FSM redline which is valid until APU start was passed with a 9.7 psia margin. After APU start this redline is reduced to 300 psia. The lower FSM pressure for RH B system did not adversely affect the APU performance.

All APU operational bands were within prescribed limits. A typical turbine speed trace and associated FSM pressure are shown on Figure 2.4.2-4. Hydrazine consumption was approximately 25% of total available. Valve times were in close agreement with STS-3 data and all redlines were comfortably passed.

Turbine exhaust and reservoir oil temperatures were not obtained since they are DFI.

TABLE 2.4.2-1 SRB TVC SUBSYSTEM OVERALL PERFORMANCE

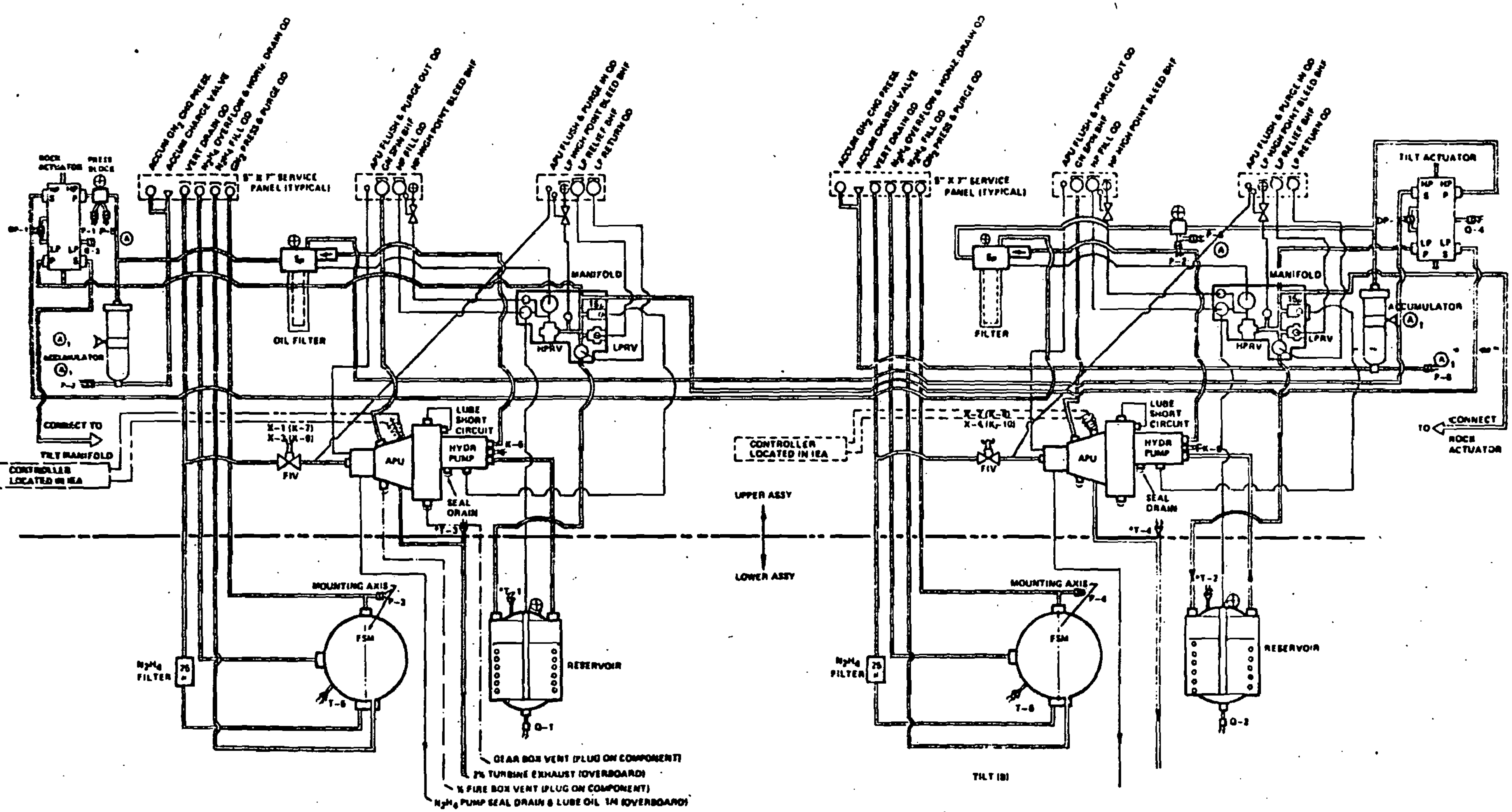
MEASUREMENT (LIMITS)	LH SYSTEM A	LH SYSTEM B	RH SYSTEM A	RH SYSTEM B
FSM PRESSURE (PSIA)				
START (300 PSIA MIN)	382.9	384.5	380.4	359.7
CUT-OFF (200 PSIA MIN)	327.9	331.9	325.2	304.6
N2H4 USED (#/GAL)	6.1/.73	5.6/.66	5.7/.68	6.2/.74
FSM TEMP (DEG F)	80	78	79	80
*HYD RES TEMP (DEG F)	-	-	-	-
*TURBINE EXHAUST TEMP (DEG F)	-	-	-	-
GG TEMP (DEG F)				
PRE-START (190-248 DEG F)	225.5	224.5	225.5	230.5
RESERVOIR LEVEL (%)				
PRE-START (60-80%)	71.6	74.2	74.6	79.0
POST-START (55-99%)	65.8	68.6	69.0	73.0
CUT-OFF	68	71.6	71.4	75.4
TURBINE SPEED (% OF 72 KRPM)				
100% (+8%)	-4.7	-4.3	-5.0	-4.4
(-8%)	+5.7	+5.3	+6.0	+6.0
110% (+8%)	+3.4	-	+2.2	-
(-8%)				
APU START (SEC)				
100% (2.7 TO 3.8 SEC)	3.24	2.76	3.00	3.24

*MEASUREMENTS NOT OBTAINED FOR THIS FLIGHT

TABLE 2.4.2-2 SRB TVC SUBSYSTEM STS-4 PRELAUNCH EVENT SEQUENCE

EVENTS	LH SYSTEM A	LH SYSTEM B	RH SYSTEM A	RH SYSTEM B
FUEL ISOLATION VALVE OPEN	-29.46	-29.14	-28.83	-28.55
SECONDARY SPEED CONTROL VALVE OPEN	-26.82	-26.66	-26.50	-26.34
BYPASS VALVE CLOSED	-21.82	-21.67	-21.50	-21.34
APU ACTIVITIES				
APU TO 110 PCT SPEED	-21.49	*	-21.29	*
SPEED BELOW 79.2 K-RPM	-20.89	*	-20.94	*
ACTIVATE 55-79.2 K-RPM	*	*	*	*
DELTA TIME	*	*	*	*
PREFLIGHT GIMBAL PROGRAM				
START	18.90	18.90	18.90	18.90
ACTUATOR POSITION UNDER +/- 0.5 IN	15.84	15.84	15.84	15.84
END	15.58	15.58	15.58	15.58
+/- .5 IN REDLINE ACTIVE				
ACTIVE HYDRAULIC PRESSURE REDLINE	*	*	*	*
2800 - 3363 PSIA	*	*	*	*

TIMES IN SEC. GMT 14:59:59.000-0
* DATA NOT AVAILABLE



ROCK SYSTEM

TILT SYSTEM

SRB TVC SUBSYSTEM
FIGURE 2.4.2-1

STS-4 DATA
LEFT HAND SRB TVC SUBSYSTEM
SYSTEM B
HYDRAULIC MEASUREMENTS

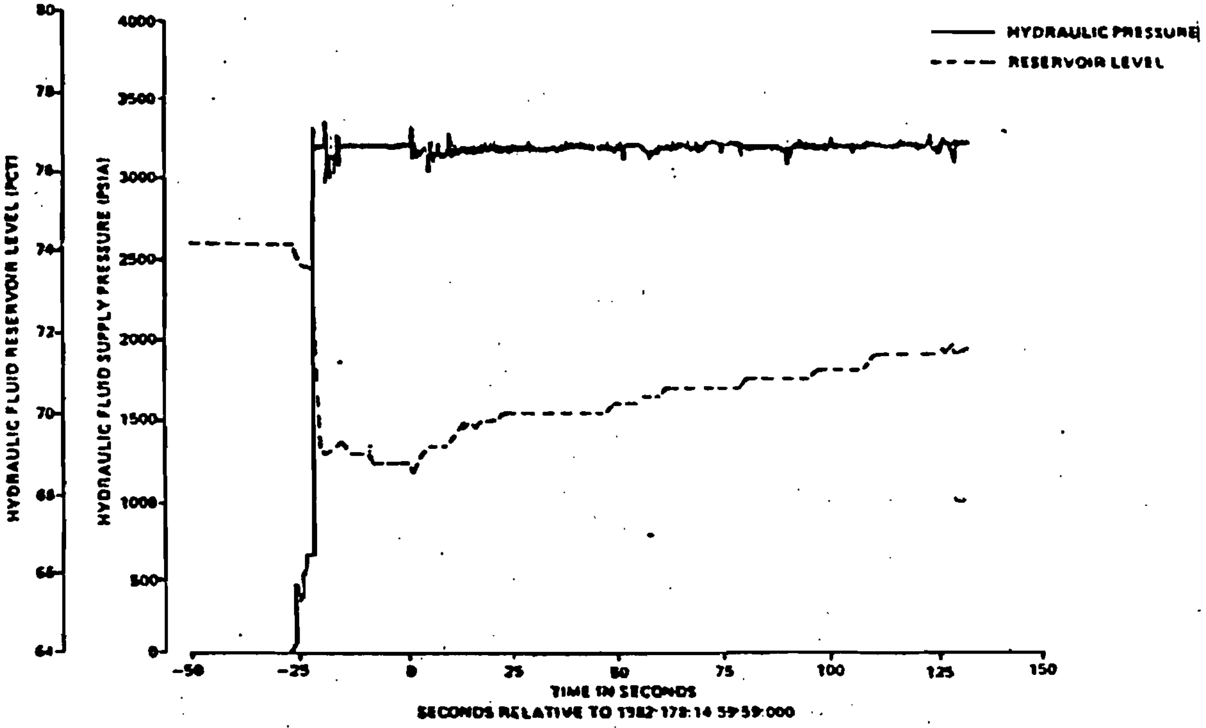


FIGURE 2.4.2-2

LEFT HAND SRB TVC SUBSYSTEM
SYSTEM B
HYDRAULIC MEASUREMENTS

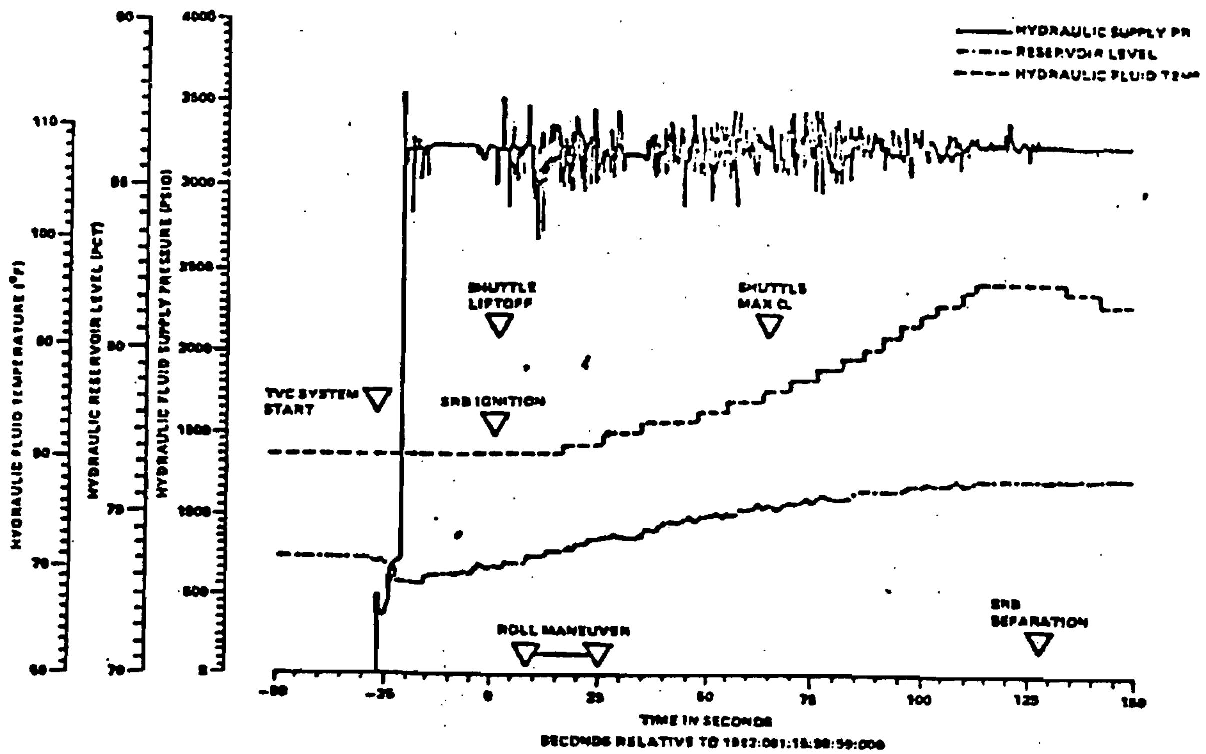


FIGURE 2.4.2-3

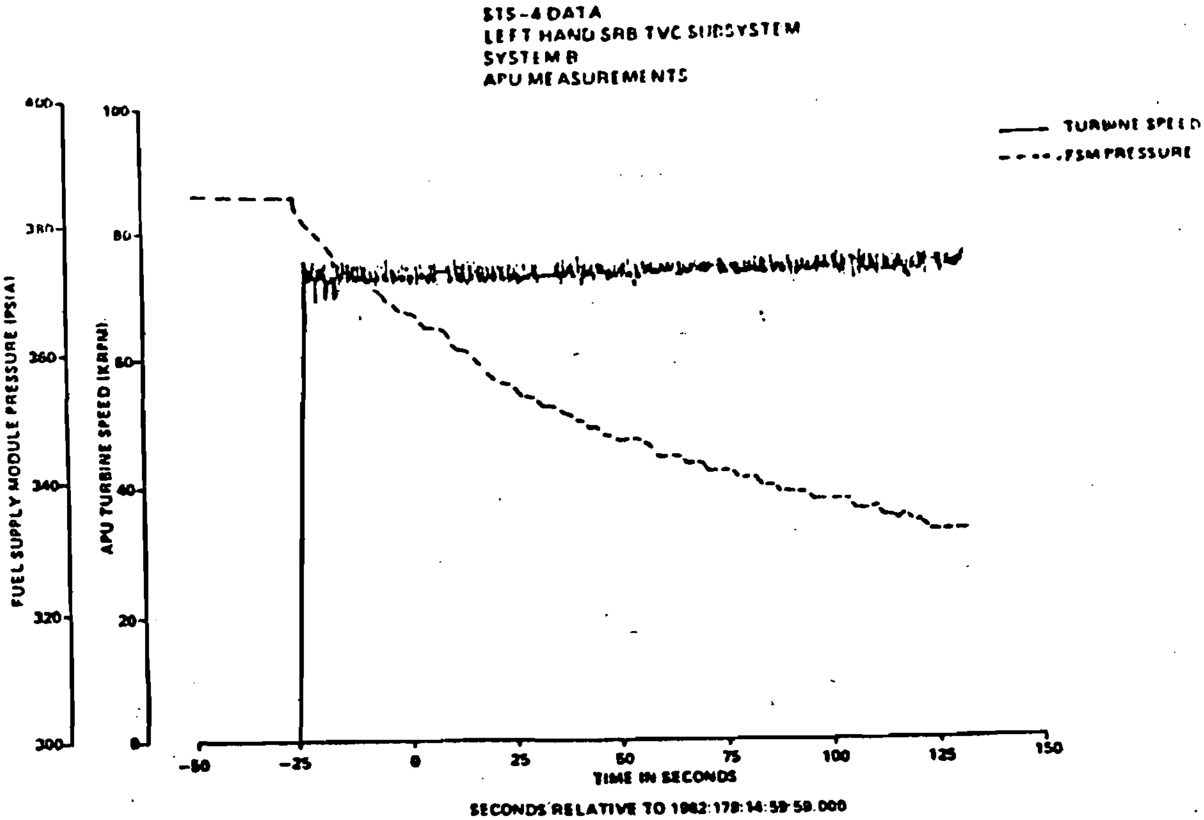

STS-4 DATA
LEFT HAND SRB TVC SUBSYSTEM
SYSTEM B
APU MEASUREMENTS
TURBINE SPEED
FSM PRESSURE
FUEL SUPPLY MODULE PRESSURE (PSIA)
APU TURBINE SPEED (KRPM)
TIME IN SECONDS
SECONDS RELATIVE TO 1982:178:14:59:59.000

FIGURE 2.4.2-4

2.5.0 STRUCTURE AND LOADS

2.5.1 SRB ASCENT LOADS VERIFICATION - The failure to recover the SRBs drastically reduced the number of structural load measurements available. The measurements available for the evaluation were:

- 16 strains on 8 MLP support posts
- 8 low frequency accelerometers -- forward skirt, mid-case, aft skirt

The MLP strain data was usable for evaluating tension and compression loads on the pads during buildup. The strain gauges were biased to allow for the tension calibration. Predicted static and design loads for the MLP support post evaluation were provided by Rockwell. A schematic of the shuttle vehicle on the launch platform giving the numbering system for the SRB support pads is shown in Figure 2.5.1-1. Figures 2.5.1-2 and 2.5.1-3 show typical response plots of the MLP support post strain for compression and tension.

The MLP strain gauges were calibrated over a short period of time, which resulted in lower calibration factors and more reliable results. The calibration factors were multiplied by the delta build-up strain and added to the static load to arrive at the total load. The lower calibration factors resulted in no exceedances for STS-4. The percent of design of compression, tension, bolt tension, and base moment were 89%, 84%, 89%, and 94%, respectively. Table 2.5.1-1 compares all four flights. Table 2.5.1-2 lists the support post tension and compression loads for all four flights and compares them to the design loads.

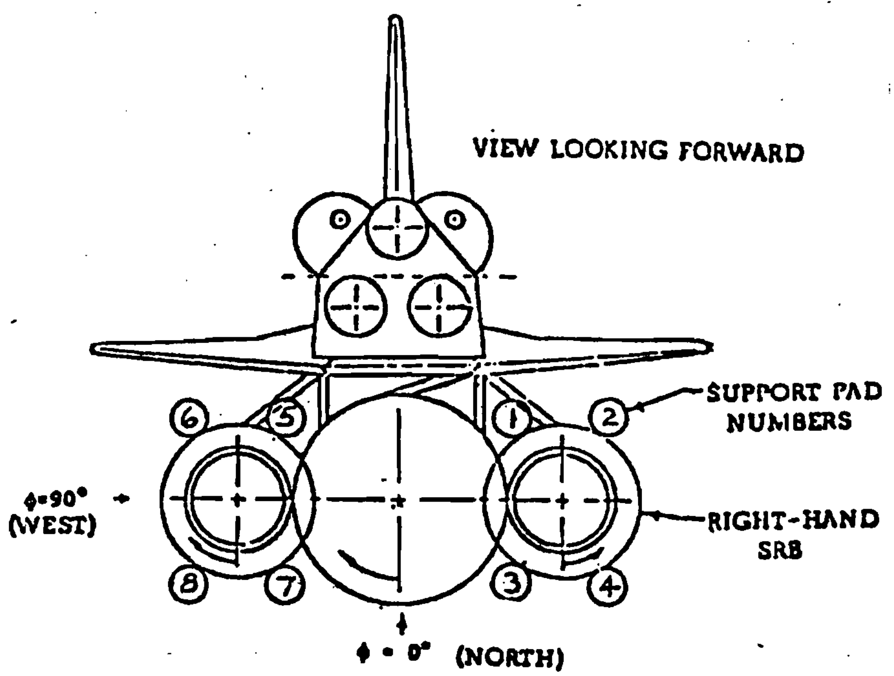
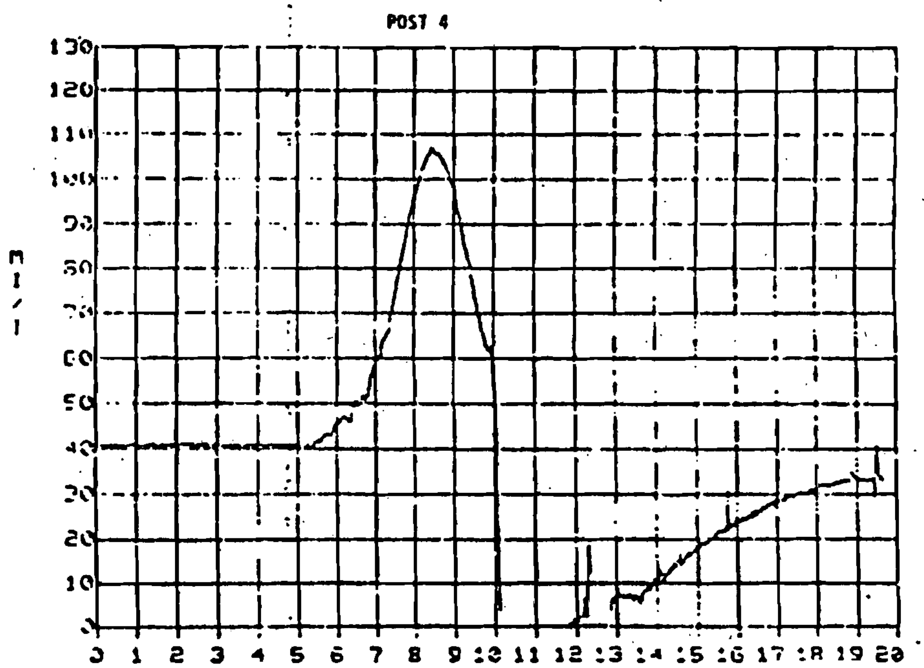


FIGURE 2.5.1-1 NUMBERING OF FACILITY/SRB SUPPORT PADS

STS-4 LAUNCH TI-INS 6 27 82

KSRGF020A SRB/HDP-M4, GAGE 2

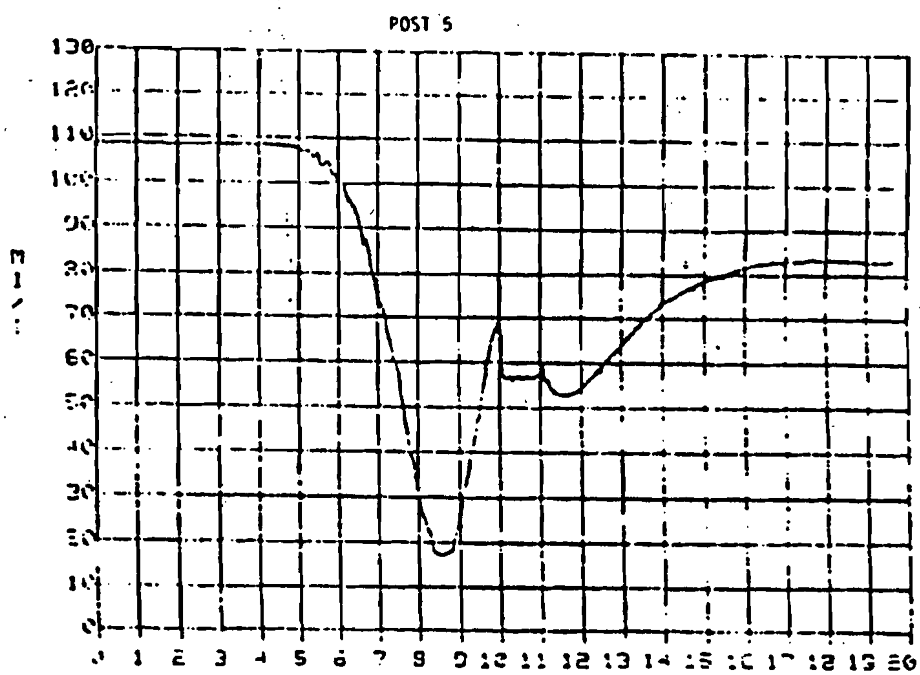


1 14:59:45.558 Z TIME (SECONDS)

Figure 2.5.1-2

STS-4 LAUNCH TI-INS 6 27 82

KSRGF021A SRB/HDP-M5, GAGE 1



1 14:59:49.998 Z TIME (SECONDS)

Figure 2.5.1-3

TABLE 2.5.1-1 FOOT PAD LOADS

	STS-1 LOAD (KIPS)	STS-2 LOAD (KIPS)	STS-3 LOAD (KIPS)	STS-4 LOAD (KIPS)	DESIGN LOAD (KIPS)	STS-4 % OF DESIGN
COMPRESSION	1368	1328	1381	1341	1355	99.0
TENSION	-	-605	-672	-527	-628	83.9
BOLT TENSION	-	918	985	840	941	89.3
BASE MOM. (10**6 IN-LB)	-334	-360	-361	-327	-347	94.2

TABLE 2.5.1-2 MLP SUPPORT POST TENSION AND COMPRESSION LOADS COMPARED TO DESIGN LOADS

POST	STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4* (KIPS)	DESIGN LOAD (KIPS)
1	CLIPPED	-560	-618	-527	-628**
2	CLIPPED	-605	-513	-422	-628
3	1265	1295	1297	1221	1355
4	1368	1328	1381	1341	1355
5	CLIPPED	-495	-458	-497	-628
6	CLIPPED	-578	-672	-487	-628
7	1280	1217	1202	1192	1355
8	1325	1247	1214	1267	1355

* INCLUDES 1.2-INCH MISMATCH AT FORWARD ET/SRB ATTACH POINT AND PRELOAD OF AFT RADIAL STRUTS.
** -628 (TENSION LOAD) = 941 (BOLT LOAD)

<u>SRB LOW FREQUENCY ACCELERATIONS</u> - Table 2.5.1-3 shows the SRB low frequency accelerations for the forward skirt, aft mid-point, and aft skirt for the right and left SRBs for liftoff and ascent flight. Only 8 out of the 13 measurements were available and only the forward accelerometer in the X-direction was usable on the left SRB. There is close agreement between STS-3 and STS-4 g levels and although STS-1 and STS-2 results were not included they were also in good agreement with the last two flights. O'grams were read for STS-1 results while data base plots have been used for the last three flights.

TABLE 2.5.1-3 SRB LOW FREQUENCY ACCELERATIONS

				LIFTOFF					ASCENT				
					STS-3		STS-4			STS-3		STS-4	
LOCATION	SRB	AXIS	SRB STA (IN)	PRED (+/-G)	MEAS. (+/-G)	FREQ. (HZ)	MEAS. (+/-G)	FREQ. (HZ)	PRED (+/-G)	MEAS. (+/-G)	FREQ. (HZ)	MEAS. (+/-G)	FREQ. (HZ)
FWD SKIRT	L	-X	426	2.6	1.55* .23 .05	- 10 4	1.50* .22 .06	- 10 4	3.5	2.50* 2.45 .05	- 3 28	2.44* 2.32 .12	- 3 30
FWD SKIRT	R	-X	426	2.6	1.57* .25 .05	- 20 4	1.55* .17 .08	- 30 4	3.5	2.50* 2.40* .10	- 3 28	2.45* 2.35 .10	- 3 30
FWD SKIRT	R	-Z	428	6.4	.23	13	.32	14	0.4	.17	26	.30	18
FWD SKIRT	R	+Y	426	6.4	.17	20	-	-	0.4	.19	26	-	-
AFT MD SEGMENT	L	-X	1191	1.9	1.58* .3 .1	- 18 4	- - -	- - -	3.5	2.58* 2.55 .03	- 3 26	- - -	- - -
AFT MD SEGMENT	R	-X	1191	1.9	1.6* .27 .07	- 20 4	1.52* .37 .08	- 20 4	3.5	2.45* 2.43 .02	- 3 24	2.38* 2.25 .13	- 3 26
AFT MD SEGMENT	L	-Z	1191	2.1	.20	20	-	-	1.1	.22	20	-	-
AFT MD SEGMENT	R	-Z	1191	2.1	.20	20	.22	20	1.1	.20	24	.22	26
AFT MD SEGMENT	L	+Y	1191	1.1	.13	10	-	-	1.1	.12	30	-	-
AFT MD SEGMENT	R	+Y	1191	1.1	.14	13	.22	14	1.1	.18	28	.22	12
AFT SKIRT	R	-X	1845	1.9	1.6* .44 .16	- 20 4	1.54* .50 .08	- 20 4	3.5	2.50* 2.38 .12	- 3 30	2.48* 2.35 .13	- 3 30
AFT SKIRT	R	+Y	1845	2.6	.29	12	.26	20	0.6	.10	22	.17	12
AFT SKIRT	R	-Z	1845	2.6	.31 .06 .3	20 14 4	- - -	- - -	0.6	.10	28	-	-

(1) X ACCELERATION IS O-PEAK (2) PREDICTED G'S ARE DESIGN CRITERIA FOR COMPONENTS (3) STS-1 AND STS-2 RESULTS COMPARED WELL WITH STS-3 AND STS-4

* PEAK X ACCELERATIONS INCLUDE 1.45g RIGID BODY AT LIFTOFF AND 2.48 FOR ASCENT

SUMMARY - The holddown post compression, tension, and bolt tension loads were 99%, 84%, and 89% of design, respectively. The base bending moment of -327 x 10**6 in. lb. was 94% of design. The lower calibration factors were responsible for the lower loads and the lower calibration factors can be traced to the short calibration time.

The low frequency SRB accelerations were close to the previous three flights, but only one measurement was available on the left SRB.

2.5.2 DESCENT AND WATER IMPACT LOADS - No data is available for this section due to loss of both SRBs.

2.6.0 PRESSURE, VIBRATION AND ACOUSTIC ENVIRONMENT

2.6.1 SRB INTERNAL PRESSURE ENVIRONMENT - No data is available for this section due to loss of both SRBs.

2.6.2 SRB VIBROACOUSTICS - Ten (10) vibration and two (2) acoustic measurements were recorded on the Orbiter tape recorder during ascent. One channel (B08D8092A, on the Aft Booster Separation Motors) showed no data during the entire flight. A data squawk has been turned in on this measurement. All of the available data compared well with the previous flights and no exceedances were noted.

27.0 SRB REENTRY AERODYNAMIC HEATING -- No data is available for this section due to loss of both SRBs.

2.8.0 STRUCTURAL/COMPONENT TEMPERATURE AND TPS EVALUATION - This section normally reports the evaluation of the Solid Rocket Booster (SRB) Thermal Protection System (TPS). The SRBs sank after splashdown and the data recorders have not been recovered, therefore the temperature limits experienced by primary structures and subsystem components have not been verified.

2.9.0 SRB ELECTRICAL AND INSTRUMENTATION SUBSYSTEM - This section presents the results of the performance evaluation of the Electrical and Instrumentation Subsystems (E&I) of both STS-4 SRBs. The elements of the E&I Subsystems under evaluation include the Operational Instrumentation (OI). Development Flight Instrumentation (DFI) data was lost when the SRBs could not be recovered. The results of the evaluation are presented in the following paragraphs.

2.9.1 TERMINAL COUNTDOWN/ASCENT PHASE ELECTRICAL AND INSTRUMENTATION PERFORMANCE - This section addresses the terminal countdown, commencing at T-5 hours countdown time, and culminating at SRB separation during the ascent phase of STS-4.

2.9.1.1 SIGNIFICANT E&I EVENTS AND TIMELINE - All significant E&I events occurred nominally with no redline violations. Table 2.9.1-1 lists significant E&I events by function and measurement description with predicted versus actual times. Requirements and comments are included as applicable. All predicted and actual times are adjusted to the FEWG data base reference time.

Generally, command times which are the predicted times for the E&I functions are not available and the functional performance is evaluated on the basis of response indications that the function has been implemented. The delay between the command and the response indication is a function of delays in processing the command and response signals as well as the sample rate of the response measurements. For the above cited reason, the evaluation of the difference between actual and command times is not always feasible. Where actual command times are used, this will be noted in the comments column. Typically, when a response indication is 1 sps, the predicted value is adjusted by 1 second to allow for measurement system response.

TABLE 2.9.1-1 SIGNIFICANT E&I EVENTS & TIMELINE

FUNCTION	MEASUREMENT DESCRIPTION	FEWG REF TIME* (SEC) PREDICTED	ACTUAL	REQUIREMENT	COMMENTS
1) (SNAPSHOT)	LH DFI ON RH DFI ON LH DFI OFF RH DFI OFF		-29,090 SEC -29,088 SEC -29,046 SEC -29,043 SEC		
2) SRB RATE GYRO ASSEMBLY (RGA) POWER ON	6 RGA POWER ON COMMANDS MONITORED BY 12 GYRO SMRD (WHEEL SPEED) INDICATIONS.	-8400	-8443 TO -8335	SMRDS ON WITHIN 120 SEC. OF POWER ON COMMAND	RGAS TURNED ON SEQUENTIALLY. DATA OF ACTUAL COMMANDS NOT AVAILABLE FOR EVALUATION
3) APU GG HEATERS ON (LH & RH)	8 GG HEATERS ON COMMANDS & 4 GG TEMPERATURE MEASUREMENTS.	-8400	-8446 TO -8445	MAINTAIN GG TEMPERATURE WITHIN A RANGE OF 190 TO 249 DEG-F.	GG HEATERS ARE CYCLED ON & OFF TILL T-30 SEC. WHEN CYCLING IS STOPPED AS NECESSARY.
4) SRB RGA TORQUE TESTS (LH & RH)	24 TORQUE CMDS (+ AND -) TO 12 GYROS MONITORED BY 12 GYRO RATE OUTPUTS.	-6600	-6565 TO -6472	+ TORQUE COMMAND: 10 +/- 2 DEG/SEC - TORQUE COMMAND: 10 +/- 2 DEG/SEC NULL: 0 +/-1 DEG/SEC	TORQUE COMMANDS ARE ISSUED SEQUENTIALLY.
5) SRB AND ET RANGE SAFETY SYSTEM (RSS) POWER ON	6 POWER ON CMDS MONITORED BY 2 BATTERY CURRENTS (ET RSS) AND 4 EVENTS (SRB RSS DECODER PWR. ON)	-3900	LH A: -3974 LH B: -3975 ET A: -3973 ET B: -3973 RH A: -3997 RH B: -3974		
6) DFI PWR. ON	2 (LH & RH) DFI POWER ON CMDS, MONITORED BY 2* DFI COMPONENT EVENTS & DFI VOLTAGES/ CURRENTS.	-720	LH: -819 RH: -812		AT DISCRETION OF THE TEST CONDUCTOR
7) ET RSS, SRB RSS, AND IGN SAFE & ARM DEVICES ARMED.	5 COMMANDS MONITORED BY 10 S&A DEVICE POSITION INDICATIONS.	-299	LH IGN: -296.8 LH RSS: -297.4 RH IGN: -296.8 RH RSS: -297.4 ET RSS: -297.2	S&A DEVICES SHOULD INDICATE ARMED WITHIN 2 SEC. OF COMMANDS.	ARMED INDICATION TIMES.
8) GROUND POWER TRANSFER	MONITORED BY 8 SRB AND 3 ORB. OI MEASUREMENTS.	-210 NOMINAL	START -238 FINISH -234		
9) REMOVE SRB DFI FLIGHT RCDR INHIBITS (LH & RH)	2 COMMANDS MONITORED BY 2 RECORDER INDICATIONS.	-49	LH: -46.44 RH: -45.44		NOMINALLY, SRB FLT. RECORDER IND. ON WITHIN 3 SEC OF CMDS.
10) SRB FDM CALIBRATION	2 COMMANDS MONITORED BY 2 FDM CAL. INDICATIONS	- 39	LH: -38.44 RH: -38.44		CAL. COMMANDS REMAIN ON.
11) SRB FWD IEA MDM LOCKOUT	4 DISCRETES FROM SRB MDM BITE STATUS REGISTERS (BSRS)	-40			DISCRETE MEASUREMENTS NOT AVAILABLE FOR EVALUATION.

*1982:178:14:59:59.000 GMT

TABLE 2.9.1-1 SIGNIFICANT E&I EVENTS & TIMELINE (CONCLUDED)

FUNCTION	MEASUREMENT DESCRIPTION	FEWG REF TIME* (SEC) PREDICTED	ACTUAL	REQUIREMENT	COMMENTS
12a) GG HTR. CMDS TURNED OFF (AS NECESSARY)	8 GG HEATER CMD. DISCRETES	-30	-28 TO -27		MANUAL COMMANDS CYCLE OFF AS NECESSARY.
12b) BYPASS VALVES TURNED ON	4 CMDS WITH NO MEASUREMENTS AVAILABLE FOR MONITORING.	-30			NO INDICATIONO AVAILABLE
12c) APU ISOLATION VALVES TURNED ON (A1 & B1 START COMMANDS)	4 CMDS MONITORED BY 8 VALVE POSITION DISCRETES.	-30	LH A: -29.441 LH B: -28.441 RH A: -28.441 RH B: -28.441		OVERALL SYSTEM PERFORMANCE COVERED IN SECTION 2-4.
13) A2 & B2 START POWER TO APU CONTROLLERS IN AFT IEAS.	4 CMDS MONITORED BY 8 EVENTS & 8 TURBINE SPEED MEASUREMENTS.	-27	LH A: -26.85 LH B: -26.61 RH A: -26.53 RH B: -26.37		OVERALL SYSTEM PERFORMANCE COVERED IN SECTION 2-4. RESPONSE TIMES.E
14) CLOSE HPU BYPASS VALVES (RESPONSE)	4 CMDS MONITORED BY SYS. PERFORMANCE (4 HYDRAULIC PRESSURES, 4 EVENTS, & 8 TURBINE SPEED MEASUREMENTS.	-22	LH A: -21.64 LH B: -21.52 RH A: -21.32 RH B: -21.20		OVERALL SYSTEM PERFORMANCE COVERED IN SECTION 2-4.E RESPONSE TIMES.E
15) TVC GIMBAL PROFILE TEST	16 COMMANDS (QUAD. REDUNDANT) WHOSE RESPONSE IS MONITORED BY VARIOUS SYSTEM MEASUREMENTS.	-20	LH ROCK: -19.04 LH TILT: -19.04 RH ROCK: -19.04 RH TILT: -19.04		OVERALL SYSTEM PERFORMANCE COVERED IN SECTION 2-4.E START OF GIMBALE PROGRAM COMMAND TIMES
16) ARM SRB IGNITION PICS	4 COMMANDS MONITORED BY 4 PIC VOLTAGE MEASUREMENTS.	-17	LH A: -16.44 LH B: -16.44 RH A: -16.44 RH B: -16.44		1 SPS DATA
17) AFT MDM LOCKOUT		-16			NO INDICATION AVAILABLE
18) SRB RSS INHIBITS OFF	4 COMMANDS MONITORED BY 4 DISCRETES.	-9	LH A: -10.041 LH B: - 9.041 RH A: -10.441 RH B: -10.441		HARDWIRE CMDS.
19) SRM IGN.	MONITORED BY 4 PIC VOLTAGE MEASUREMENTS	1(NOM.)	LH A: + 1.343 LH B: + 1.343 RH A: + 1.343 RH B: + 1.343		1 SPS DATA
20) SRB RSS SYSTEMS SAFED & POWERED DOWN	6 CMDS (4 TO SAFE, 2 RSS S&A DEVICES) MONITORED BY 8 INDICATIONS & 4 CURRENT MEASUREMENTS		LH RSS: 124.8 RH RSS: 124.8 LH S&A: 124.8 RH S&A: 125.0		5 SPS DATA
21) SRB SEPARATION ARM	24 SEPARATION PIC VOLTAGES	125.3	129		5 SPS DATA
22) SRB SEPARATION	24 SEPARATION PIC VOLTAGES	127	N/A		

*1982:178:14:59:59.000 GMT

2.9.1.2 <u>LAUNCH COUNTDOWN REDLINE REVIEW</u> - There were no launch countdown redline violations.

2.9.1.3 <u>OI BUS VOLTAGE SUMMARY AND REVIEW</u> - For the STS-4 final countdown and ascent, all SRB and Orbiter Bus voltage measurements were within specification. Figures 2.9.1-1 and 2.9.1-2 are applicable voltage plots.

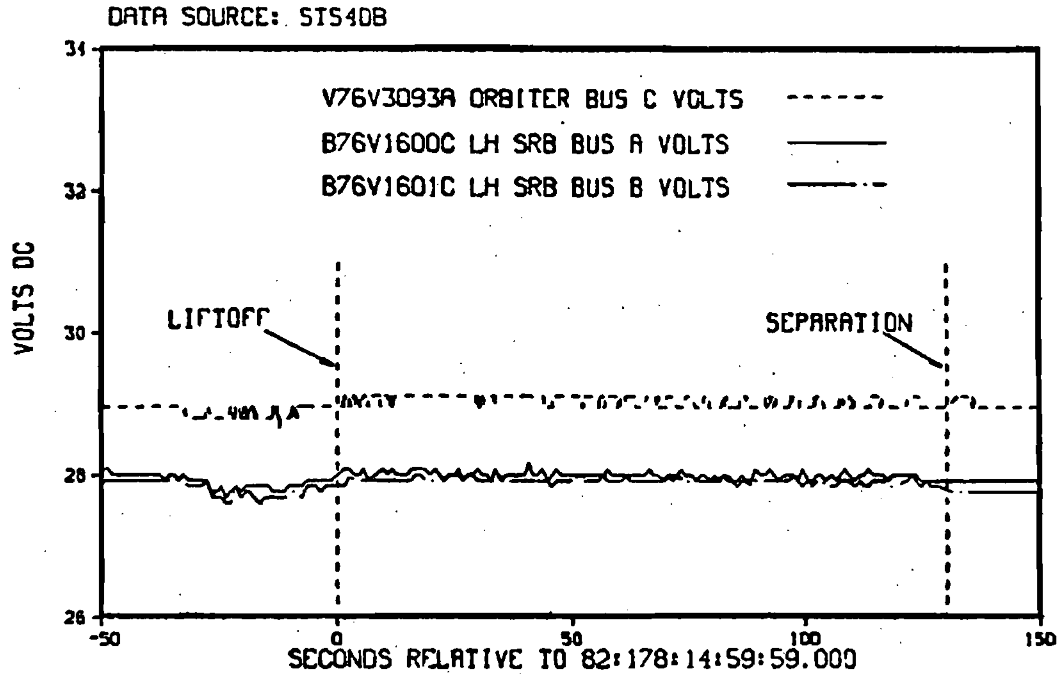


FIGURE 2.9.1-1 LH SRB OPERATIONAL BUS VOLTAGES

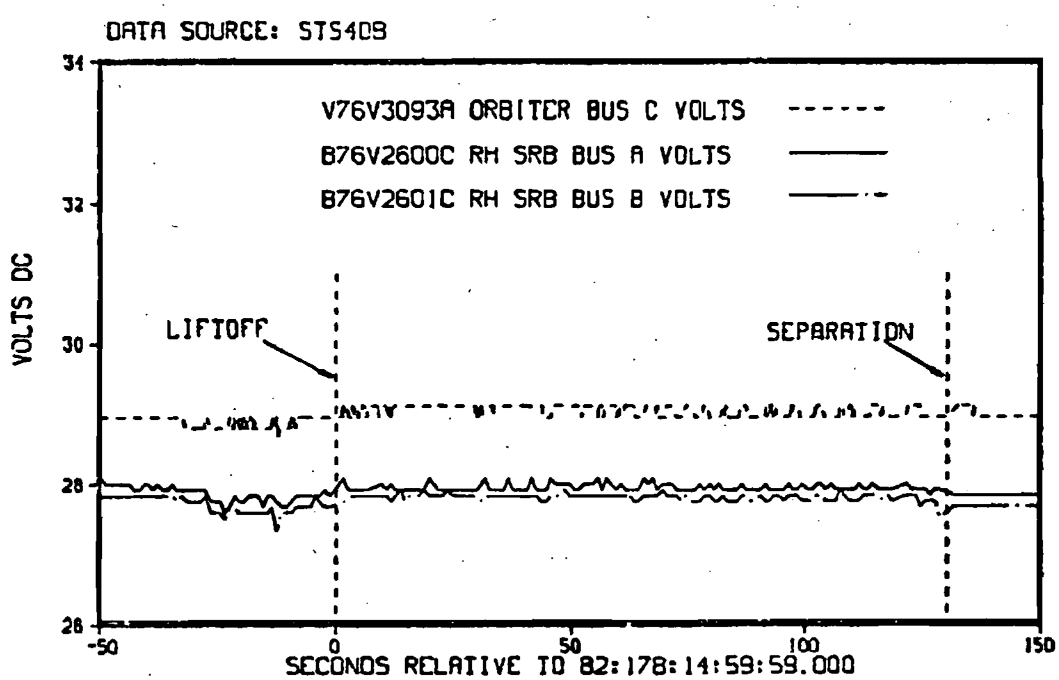


FIGURE 2.9.1-2 RH SRB OPERATIONAL BUS VOLTAGES

ICD 2-14001 has a transient voltage requirement that the lower voltage limit shall not exceed 1 VDC below the specified steady state voltage or an upper value of 36.7 volts for .02 seconds with decay to steady state values within .2 seconds. Since the voltage measurement sample rate is 1 sps, the data would not reflect a voltage transient should it occur.

There are no dedicated SRB current measurements and the resolution of the Orbiter bus current measurements is not sufficient for an evaluation of nominal SRB loads.

2.9.1.4 IEA PERFORMANCE - Each SRB is equipped with one forward and one aft IEA (Integrated Electronics Assembly). The IEAs provide the interface between the various SRB and Orbiter subsystems. All IEA functions performed satisfactorily during countdown and ascent mission phases.

IEA MDM AND HARDWARE COMMAND AND RESPONSE DATA - The IEAs have provision for accepting, implementing, and outputing the response for certain critical functions through redundant hardwire connections. Examples of this are the redundant SRM Ignition Arm and Fire Commands.

On the basis of available data, all required MDM and hardwire command and response functions were successfully performed during STS-4.

SRB IEA RGA CONTROLS - The FWD SRB IEA controls and measurements for the 6 rate gyro assemblies (RGAs) performed nominally for the STS-4 mission. RGA functions provided by the FWD IEAs include RGA "Power ON" commands with associated switches, RGA torque test commands, discrete measurements and various hardwire interfaces.

SRB IEA APU CONTROLS - Each aft SRB IEA includes two APU controllers for the dual HPU systems A and B, 2 APU BITE (Built-In Test Equipment) assemblies, and associated command and signal conditioning circuitry. The overall system performance, including related electronics, is discussed in Section 2.4.2. In summary, regulation of the APU turbine shaft speed was +/- 8%, which indirectly indicates the APU controller operated properly within the overall control system. The APU BITE system performed nominally during the final STS-4 countdown, although it is not operated during the terminal portion of the countdown. Measurements which define the command state of the APU BITE Assemblies are not available for evaluation.

THRUST VECTOR CONTROL CIRCUITRY AND MEASUREMENTS - Each SRB aft IEA contains provision for hardwire commands, measurements and signal conditioning to support the Thrust Vector Control (TVC) subsystem and its redundant hydraulic subsystems. The overall performance of this subsystem is discussed in Section 2.4.1. The TVC E&I subsystem performance was satisfactory.

SRM IGNITION FUNCTIONS - The SRB forward IEA controls and measurements related to SRM Ignition S&A Devices and PICs performed nominally during the STS-4 launch.

SRM IGNITION S&A DEVICE FUNCTIONS - Although command times are not available, the LH and RH Ignition S&A devices were observed to change state near the nominal predicted time. Both S&A Devices changed position from safed to armed within 0.4 seconds. Although the requirement that the ignition S&A devices change state within 2 seconds cannot be directly verified, it can be inferred, since no redline violations were reported for this function. This in turn indicated the IEA circuitry which drives the S&A devices performed as required.

SRM IGNITION PERFORMANCE - The SRM Ignition PICs performance appeared nominal. The requirement is that the LH and the RH SRM ignition occur within 9.4 ms of each other. Since loss of SRBs resulted in loss of DFI high sample rate data, no high-resolution analysis can be obtained on this flight. There was, however, no indication of excessive ignition timing skew.

SRB SEPARATION PERFORMANCE - Based on available data, all E&I subsystem SRB separation functions performed nominally. The OI data has separation PIC voltage data for the redundant channel A separation PICs (6 RH SRB and 6 LH SRB) at a 5 sps rate while the other 12 LH and RH channel B separation PICs are sampled at a 1 sps rate. The 5 sps data showed separation PIC arming for the LH and RH channel A separation PICs in process at 129.000 seconds. The 1 sps data for the LH and RH channel B separation PICs also indicated arming in process. The data showed all separation PIC armed to a nominal 38 volt level.

As was observed in the first 3 flights, the OI data did not register the separation PICs firing. Correlating measurements indicates that separation for both LH and RH SRBs occurred at 130.77 seconds. This is consistent with the normal interval between separation PIC arm and fire commands (nominally 1.7 seconds) and past flight data. The indications are that the SRB separation sequence for STS-4 was nominal.

DFI CONTROL AND MEASUREMENTS - The forward IEA MDMs provide DFI subsystem commands to apply and remove DFI power, auto calibrate the DFI Frequency Division Multiplexers (FDMs), and to inhibit recording or reverse the SRB DFI flight tape recorders. Within the OI MDM data system these functions may be monitored by various DFI component power ON discretes. DFI battery voltage and current measurements, and status discrete indications for the SRB tape recorder and FDM auto calibrate functions. During the final countdown and ascent mission phases, performance for these functions was acceptable.

RSS CONTROL AND MEASUREMENTS - The forward SRB IEAs provide various functions for the SRB and ET Range Safety Systems (RSS) from the final hours of countdown through ascent. Performance for these functions with respect to the F&I subsystem was nominal. RSS functions provided by the forward IEAs include command processing for power, inhibits, and RSS S&A device positioning with associated measurement capability.

2.9.1.5 SRB RATE GYRO PERFORMANCE - Prelaunch SRB rate gyro performance was nominal with rate gyro nulls typically holding within +/- 1 count (.04 deg/sec absolute) and torque tests successfully completed. No SMRD dropouts occurred.

All indications are that the 6 SRB rate gyro assemblies on STS-4 operated satisfactorily during all mission phases.

In STS-4, procedures were implemented in the mounting and alignment of the SRB rate gyro mounting plates. These procedures reduced the axis cross coupling effects experienced in previous flights to well within specification.

In summary, from available data, all SRB rate gyros operated satisfactorily.

2.9.1.6 ENVIRONMENTAL PARAMETERS - In general, data for the thermal and dynamic environments that the SRB E&I components are subject to are acquired by the LH and RH SRB DFI data systems. As these data are not currently available, no statements regarding these parameters may be made.

2.9.2 INSTRUMENTATION PERFORMANCE - There are two systems on each SRB monitoring SRB performance and environmental conditions, the Operational Instrumentation (OI) and Development Flight Instrumentation (DFI). The OI provides the capability to accomplish prelaunch checkout and limited performance assessment during the boost phase of flight.

DFI supplements OI instrumentation and provides additional capability to evaluate SRB performance and design limits against actual flight regimes of liftoff, boost, reentry and splashdown.

This section of the report contains an appraisal of the performance of the sensors used in both the OI and DFI.

2.9.2.1 OI SENSORS - Table 2.9.2-1 summarizes the measurements available during the launch and boost portion of the flight. All OI sensors were operative to separation.

TABLE 2.9.2-1 SUMMARY OF SRB MEASUREMENTS MADE THROUGH OI SYSTEM DURING LAUNCH AND BOOST PHASES OF MISSION

TYPE	A13 MEASUREMENTS OI	A13 MEASUREMENTS DFI*	A14 MEASUREMENTS OI	A14 MEASUREMENTS DFI*	TOTAL MEASUREMENTS OI	TOTAL MEASUREMENTS DFI*
VOLTAGE	26	1	26	1	52	2
CURRENT	2	1	2	1	4	2
TEMPERATURE	5	2	5	2	10	4
PRESSURE	7		7		14	
EVENTS	70	16	70	16	140	32
RATE	4		4		8	
LEVEL	2		2		4	
POSITION	2		2		4	
	2		2		4	
TOTALS	120	20	120	20	240	40

* DFI SYSTEM MEASUREMENTS MONITORED THROUGH OI SYSTEM.

2.9.2.2 DFI SENSORS – The baselined SRB design scheduled 604 DFI measurements to be made on STS-4 A13 and A14. Table 2.9.2-2 contains a summary of the measurements by parameters for A13 and A14.

TABLE 2.9.2-2 BASELINED DFI MEASUREMENTS

TYPE	LH SRB MEASUREMENTS	RH SRB MEASUREMENTS	TOTAL MEASUREMENTS
VOLTAGE	26	26	52
CURRENT	2	2	4
TEMPERATURE	38	55	93
PRESSURE	59	56	115
HEAT FLUX	50	26	76
ACCELERATION	3	3	6
RATE	3	3	6
VIBRATION	26	40	66
ACOUSTIC	6	6	12
FORCE	20	20	40
STRAIN	16	24	40
EVENTS	44	44	88
TIME CODE	1	1	2
POSITION	2	2	4
TOTALS	296	308	604

Prior to launch, eleven (11) measurements were determined to be inoperative or inaccurate, and were waived by KSC with MSFC concurrence and subsequent change board approval. These measurements are listed in Table 2.9.2-3.

TABLE 2.9.2-3 SRB DFI MEASUREMENTS WAIVED FOR STS-4

MSID	MEASUREMENT NOMENCLATURE	WAIVER NO
B07T8518A	TEMP., ET ATTACH STRUT, MID AFT	81-781
B08D7079A	VIB, AFT SKIRT INTERNAL, RADIAL DIR.	81-782
B08D8085A	VIB, NOSE CONE EQUIP. TANG. DIR.	81-786
B08D8122A	VIB, THERMAL CURTAIN	81-788
B08P8317A	PRESS., AFT SKIRT INTERNAL #2	81-789
B08Y8986A	ACOUSTIC, AFT SKIRT HEAT SHIELD EXT.	81-790
B08D8092A	VIB, AFT SEPARATION MOTOR, RADIAL DIR.	81-791
B08P8315A	PRESS., AFT BULKHEAD	81-792
B08D8121A	VIB, INPUT TO TVC LOWER FRAME RADIAL DIR	81-793
B08D8094A	VIB, AFT BULKHEAD, TANGENTIAL DIR.	81-794
B08G7200A	FORCE, MAIN CHUTE 1, ATTACH PT. 1	81-795

Due to the decelerator system problem, all DFI measurements stored by the DFI recorder on both SRBs were lost. SRB DFI data measured at both FDM1MUX1's were collected and stored on the Orbiter In-flight recorder up to separation. Table 2.9.2-4 lists these measurements. Measurement responses appear normal except as indicated.

TABLE 2.9.2-4 SRB DFI DATA STORED ON ORBITER RECORDER (TO SEPARATION)

MSID	DESCRIPTION	NOTES
B08D7070A	LH VIB FWD E&I EQUIPMENT -X AX(L) SNSR A	
B08D7073A	LH VIB MID SIDEWALL -X AX(L) SNSR A	(1)
B08D7074A	LH VIB MID SIDEWALL -Z AX(R) SNSR A	(2)
B08D7075A	LH VIB MID SIDEWALL +Y AX(T) SNSR A	(2)
B08D7079A	LH VIB AFT SKT INTERNAL RADIAL DIR	
B08D7083A	LH VIB NOSE CONE EQPT. RADIAL DIR	
B08D7123A	LH VIB INPT ROCK ACTR AFT SKT ATTACH FLT DIR	
B08D7124A	LH VIB INPT ROCK ACTR AFT SKT ATTACH RDL DIR	
B08D7125A	LH VIB TVC UPPER FRAME . . . . FLT DIR	
B08P7315A	LH PRESS AFT BULKHEAD	
B08D8070A	RH VIB FWD E&I EQPT. FLT DIR SNSR A	
B08D8071A	RH VIB FWD E&I EQPT. -Z AX(R) SNSR A	
B08D8073A	RH VIB MID SIDEWALL -X AX(L) SNSR A	
B08D8074A	RH VIB MID SIDEWALL -Z AX(R) SNSR A	
B08D8075A	RH VIB MID SIDEWALL +Y AX(T) SNSR A	
B08D8076A	RH VIB AFT SKIRT -X AX(L) SNSR A	
B08D8077A	RH VIB AFT SKIRT -Y AX(R) SNSR A	
B08D8079A	RH VIB AFT SKIRT INT. FLT DIR	
B08D8083A	RH VIB NOSE CONE EQPT RDL DIR	
B08D8086A	RH VIB AFT SKT P ACTR ATTACH NOR DIR	(1)
B08D8089A	RH VIB FWD SEPN MOTOR RDL DIR	
B08D8092A	RH VIB AFT SEPN MOTOR RDL DIR	(3)

NOTES: (1) THESE MEASUREMENTS SHOW EXCESSIVE GAIN - PROBABLY DUE TO IMPROPER SIGNAL CONDITIONER GAIN LEVELS.
(2) THESE MEASUREMENTS APPEAR TO HAVE BEEN MOUNTED IN THE WRONG AXIS (AS COMPARED TO RESPONSES FROM PREVIOUS FLIGHTS).
(3) THIS MEASUREMENT WAIVED PRIOR TO FLIGHT PER 81-791.

2.9.2.3 <u>STS-4 MEASUREMENT SYSTEM PERFORMANCE EVALUATION</u> - A total of 240 OI measurements (100%) performed properly throughout their respective mission phases. All 604 DFI measurements were lost due to loss of SRBs with the exception of measurements contained in both FDM1MUX1's (which were recorded on the Orbiter In-Flight Recorder up to separation as outlined in Para. 2.9.2.2).

2.9.3 RECOVERY PHASE OI ELECTRICAL PERFORMANCE - Analysis of Recovery Battery Current and Voltage profiles indicate nominal loading for preflight, RSS sytem turn-on through RSS sytem turn-off and separation. USNS Vandenberg uncorrected preliminary tracking data indicate nominal nose-cap release times (346.6 sec.:LHSRB and 345 sec.:RHSRB). Vandenberg data also indicate nominal Frustum Separation (373 sec.:LHSRB and 367 sec.:RHSRB) (estimated times) and indicates Water Impact times to be: 385 sec.:LHSRB and 378 sec.:RHSRB. All times are relative to lift-off. There are no SRB DFI data available at this time to support any of the above observations.

2.9.4 DEVELOPMENT FLIGHT INSTRUMENTATION DATA ACQUISITION SYSTEMS - Each SRB on STS-4 contained an independent, onboard DFI data acquisition system to condition and record measurements on SRB performance and environmental conditions during the last stages of countdown and flight. The DFI data acquisition system included signal conditioning, Pulse Code Modulation (PCM) Multiplexer and Frequency Division Multiplexers (FDM), multi-channel tape recorder, time code generator, power distribution and control, and independent battery power. The DFI data acquisition system interfaces with the SRB OI system for controls and selected measurements. Its principal operating period is from approximately forty seconds prior to liftoff through boost and reentry to 300 seconds after splashdown.

2.9.4.1 DFI DATA ACQUISITION SYSTEM COMPONENT PERFORMANCE - The DFI data acquisition system operated satisfactorily through separation. In the event of subsequent recovery of SRB DFI Flight Recorders, this report will be appended as data become available.

2.9.4.2 DFI DATA ACQUISITION SYSTEM ELECTRICAL POWER - DFI Battery temperature conditions were available from OI measurements up to SRB separation. These data are shown in Table 2.9.4-1. During this period, the battery temperature were within required limits.

TABLE 2.9.4-1 DFI BATTERY TEMPERATURES (DEG F)

DESCRIPTION	LOWER LIMIT	ACTUAL MIN.	ACTUAL MAX.	UPPER LIMIT
B76T7529C LH TEMP DFI BATTERY	34	77.5	78.5	120
B76T8529C RH TEMP DFI BATTERY	34	78.5	79.5	120

2.10.0 SRB SEPARATION SUBSYSTEM PERFORMANCE – Loss of DFI tape recorder data resulted in no analysis of BSM pressure performance curves. Available photographic data and visual inspection reviews indicate no debris from the BSMs during STS-4 separation. The one FWD BSM cover, which was missing after A14 water impact, was determined to have been lost during reentry.

2.11.0 REENTRY AND RECOVERY

2.11.1 POST SEPARATION DYNAMICS AND TRAJECTORY

2.11.1.1 SUMMARY - Each SRB had reentry characteristics similar to the nominal predicted values until the end of the drogue parachute phase. Thereafter, recovery system malfunctions caused the loss of both SRBs due to extremely high water impact velocities.

2.11.1.2 DATA ACQUISITION - The tracking ship USNS Vandenberg was stationed near the impact zone to provide reentry radar tracking and photographic data. A separate radar track was obtained for each SRB from separation to just before splashdown. Cloud cover and haze caused several gaps in the Vandenberg photographic coverage. No main parachute phase photographic data were obtained from the Vandenberg, except for a few frames of the left SRB just before and including splashdown.

The sinking of each SRB after splashdown caused the loss of recorded reentry data, such as event times and Separation Instrumentation Package rate gyro data.

2.11.1.3 TRAJECTORY - The measured reentry trajectory of each SRB was similar to the nominal predicted trajectory through the drogue parachute phase. The measured apogee was 226,000 feet for each SRB at T+199 seconds. The nominal predicted apogee was 231,000 feet at T+197 seconds.

Figures 2.11.1-1 and 2.11.1-2 compare the altitudes of the right and left SRBs, respectively, to that of the nominal predicted trajectory.

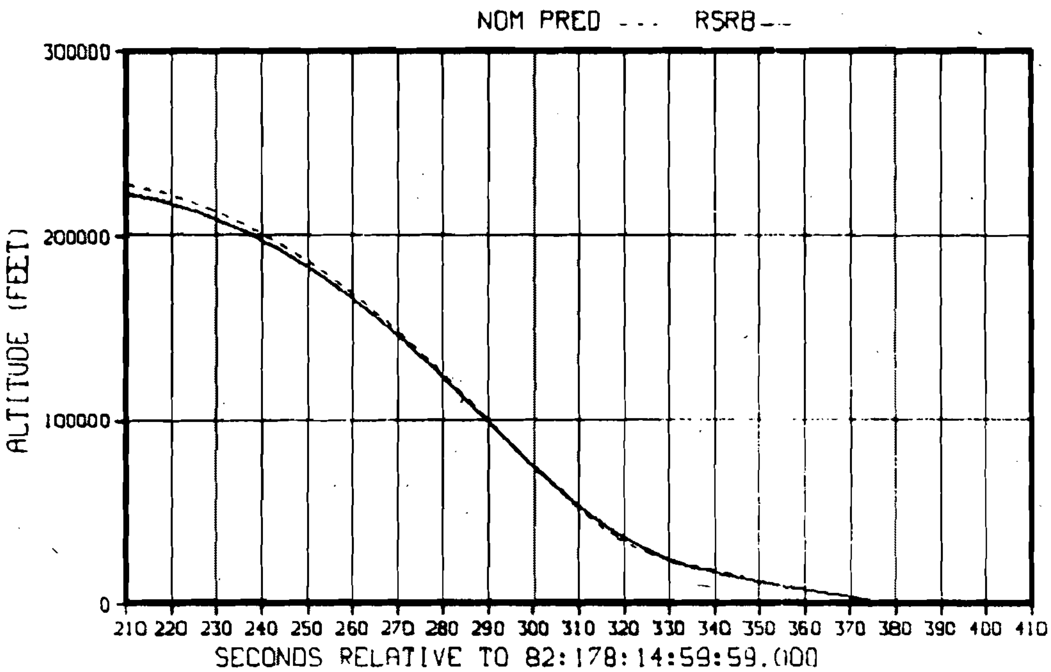


FIGURE 2.11.1-1 RH SRB MEASURED & NOMINAL PREDICTED ALTITUDE

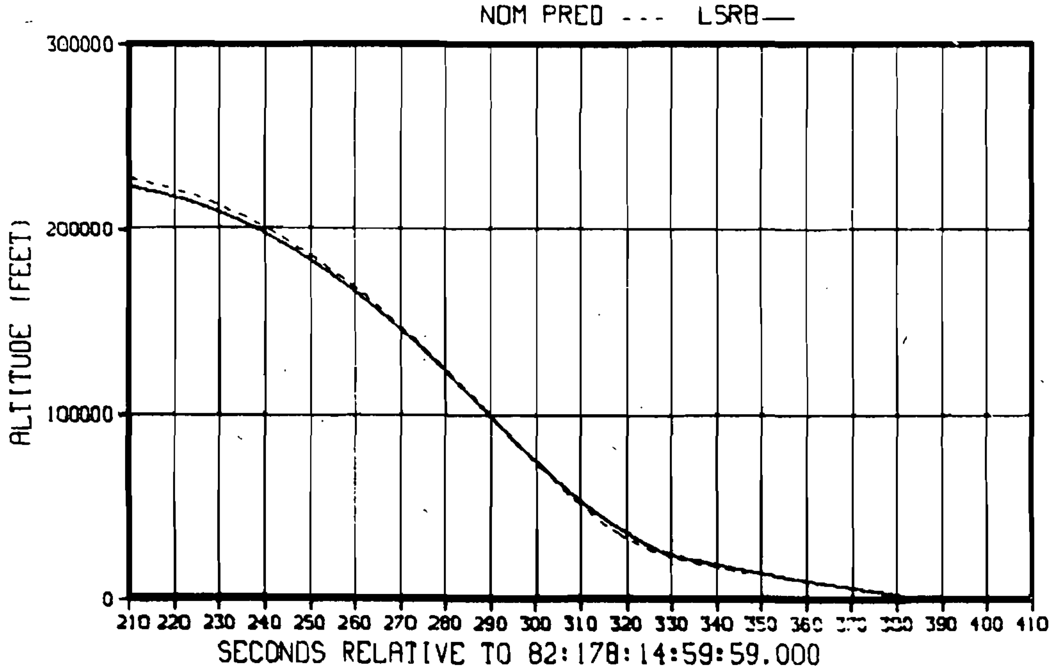


FIGURE 2.11.1-2 LH SRB MEASURED & NOMINAL PREDICTED ALTITUDE

Figures 2.11.1-3 and 2.11.1-4 compare the measured dynamic pressures of the right and left SRBs, respectively, to that of the nominal predicted trajectory. The peak measured values of dynamic pressure for both SRBs during reentry were slightly lower than the nominal predicted peak value, but within the predicted limits.

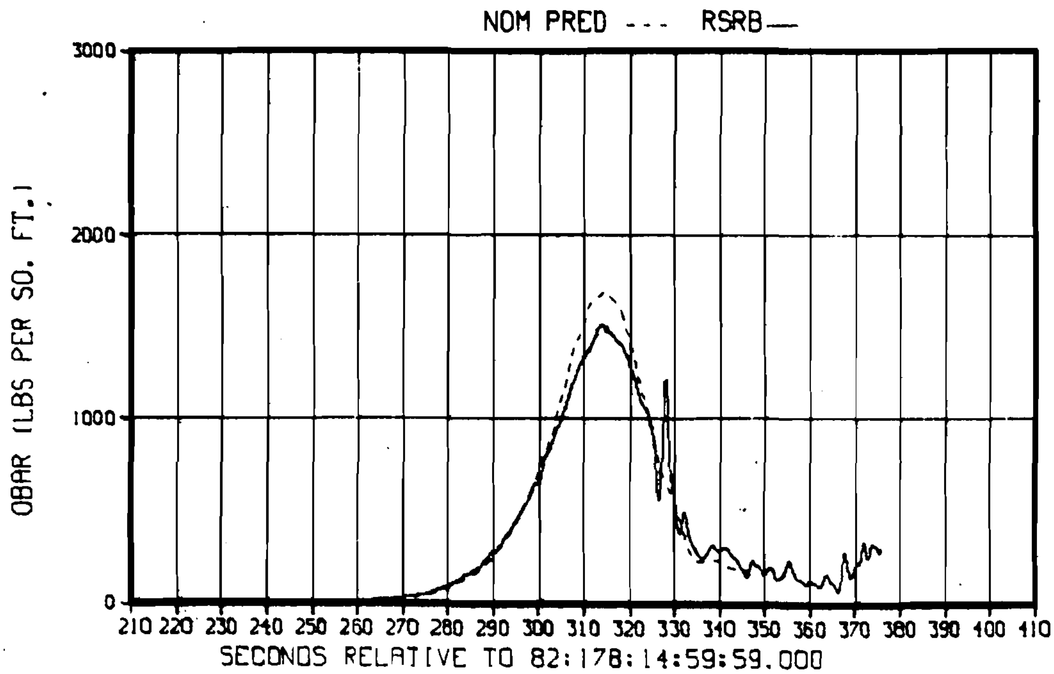


FIGURE 2.11.1-3 RH SRB MEASURED & NOMINAL PREDICTED DYNAMIC PRESSURE

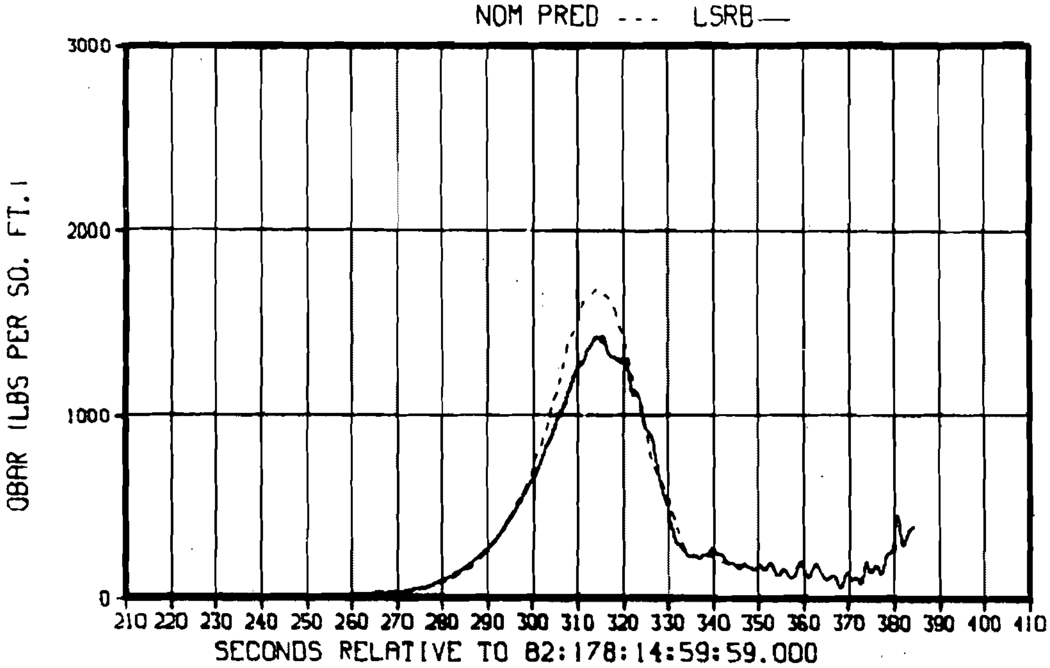


FIGURE 2.11.1-4 LH SRB MEASURED & NOMINAL PREDICTED DYNAMIC PRESSURE

The measured Mach number histories of both SRBs are compared to that of the nominal predicted trajectory in Figures 2.11.1-5 and 2.11.1-6.

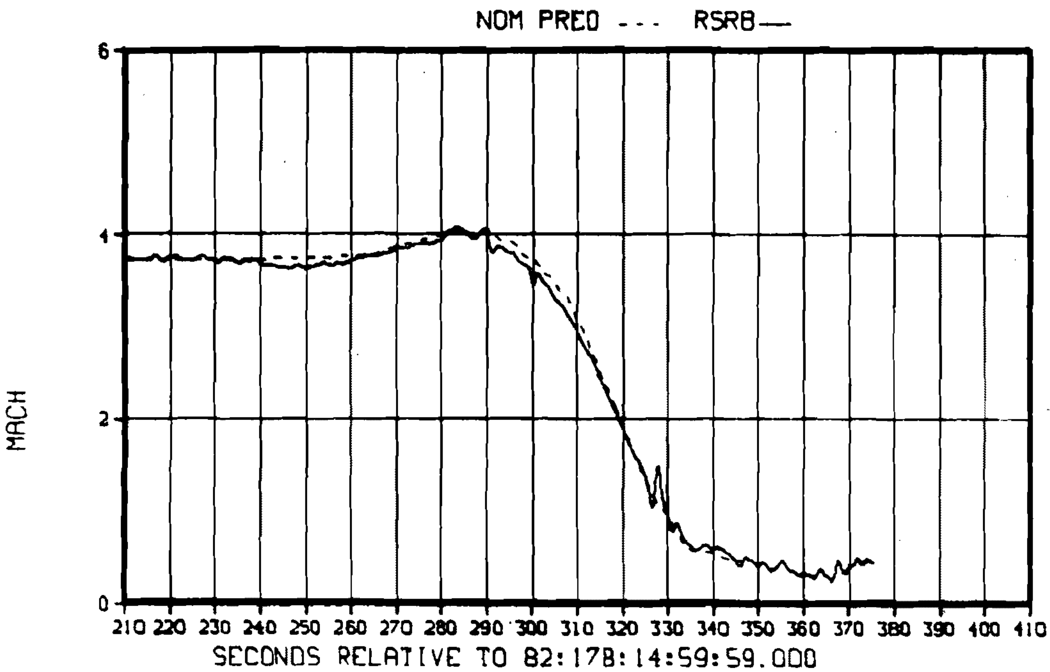


FIGURE 2.11.1-5 RH SRB MEASURED & NOMINAL PREDICTED MACH NUMBER

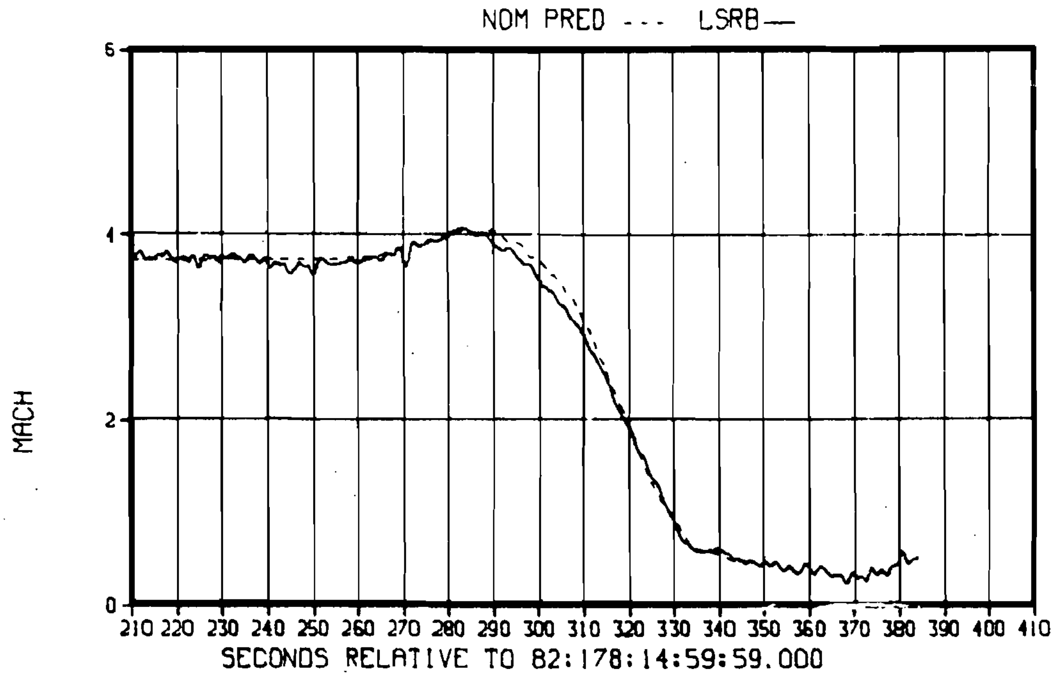


FIGURE 2.11.1-6 LH SRB MEASURED & NOMINAL PREDICTED MACH NUMBER

At T+328 seconds, approximately 12 seconds after each SRB passed through peak dynamic pressure, the SRBs crossed paths within a few hundred feet of each other. Collision analyses over the past five years have shown the possibility of such a crossing, but the probability of actual contact is very low and is not cause for alarm.

Each SRB had favorable conditions for drogue parachute deployment. The approximate times of the nose-cap separations were T+346 seconds for the right SRB and T+348 seconds for the left SRB. The measured dynamic pressures at the nose-cap separations were approximately 215 and 175 psf for the right and left SRBs, respectively, compared to the nominal predicted value of 189 psf. The approximate altitudes at the nose-cap separations were 14,741 feet for the right SRB and 16,469 feet for the left SRB, both within the predicted limits.

The SRBs and frustums impacted within the predicted footprints. Each nozzle extension was probably still attached at water impact, due to the extremely short time between frustum release and water impact of each SRB. The impact coordinates for the right SRB were 28.673 degrees north, 78.035 degrees west; and for the left SRB were 28.674 degrees north, 78.020 degrees west. Relative to the nominal predicted impact points, the right SRB impacted 3.4 nautical miles uprange and the left SRB impacted 2.6 nautical miles uprange. Each frustum impacted within 500 yards of the corresponding SRB.

2.11.1.4 VEHICLE DYNAMICS - The measured angle of attack of each SRB during reentry was consistent with that measured on the previous flights, and very close to that of the nominal predicted STS-4 trajectory.

Figures 2.11.1-7 and 2.11.1-8 compare the measured angles of attack of the right and left SRBs, respectively, to that of the nominal predicted trajectory. At nose-cap separation, the approximate angle of attack for the right SRB was 113 degrees and for the left SRB was 133 degrees, both within the predicted limits.

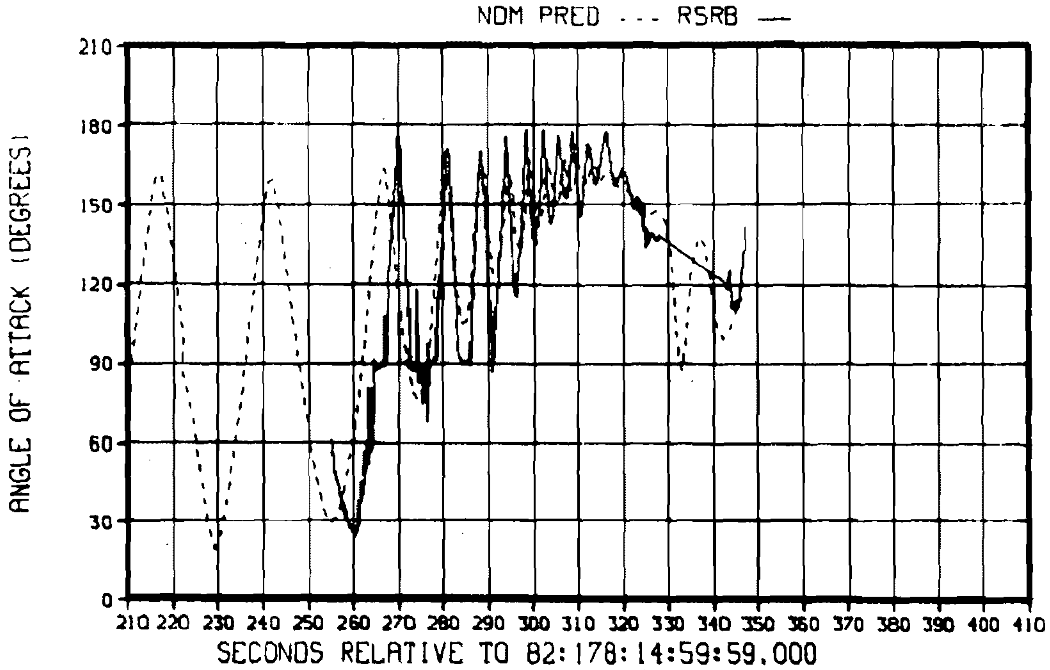


FIGURE 2.11.1-7 RH SRB MEASURED & NOMINAL PREDICTED ANGLE OF ATTACK

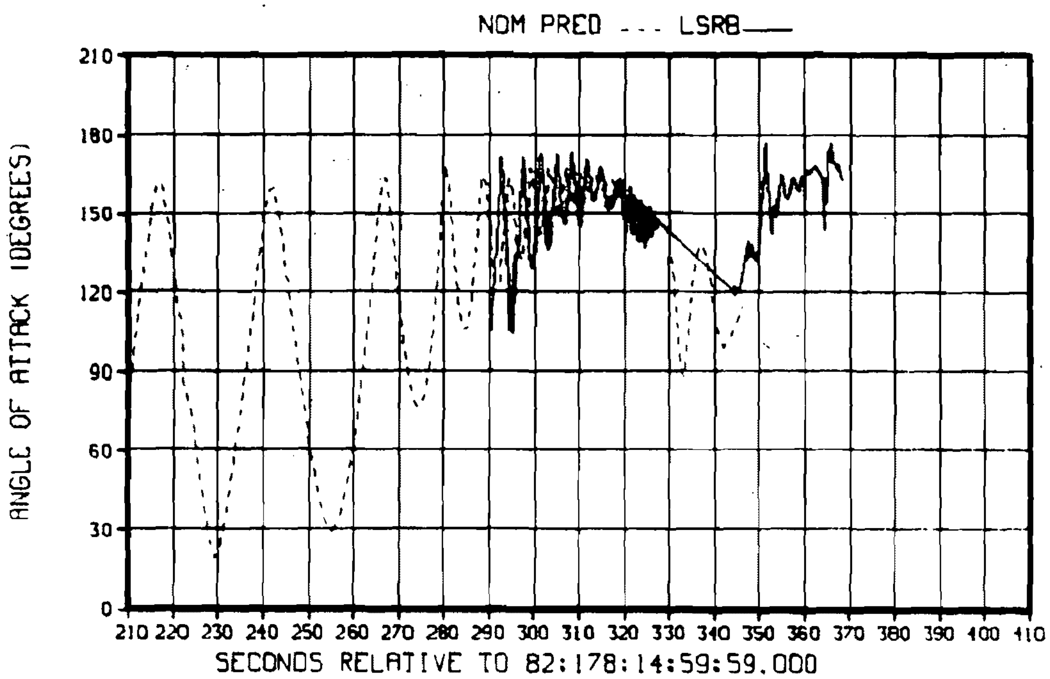


FIGURE 2.11.1-8 LH SRB MEASURED & NOMINAL PREDICTED ANGLE OF ATTACK

No angular rate information was available because of the loss of both SRBs. Based on the peak measured values of dynamic pressure for both SRBs, the tumble rates imparted just after SRB separation were probably similar to the nominal predicted value of 14 degrees per second.

3.0 EXTERNAL TANK EVALUATION

3.1.0 ET FLIGHT SUMMARY

3.1.1 FLIGHT OBJECTIVES AND ACCOMPLISHMENTS - Table 3.1.1-1 summarizes the STS-4 objectives pertaining to the ET along with the degree of accomplishment and discrepancies for each objective.

TABLE 3.1.1-1 ET OBJECTIVES AND ACCOMPLISHMENTS

OBJECTIVES	DEGREE OF ACCOMPL	DISCREPANCIES
3.2.0 LO2 SLOSH DAMPING		
EVALUATE THE ADEQUACY OF THE LO2 TANK SLOSH BAFFLING. DETERMINE IF SIGNIFICANT SLOSH INTERACTION IS PRESENT IN THE VEHICLE DYNAMIC RESPONSE AND IF SO COMPARE FLIGHT RESPONSES WITH PREDICTED RESPONSE WHEN FORCED BY THE MEASURED FLIGHT WIND.	COMPLETE	NONE
3.3.0 STRUCTURE AND LOADS		
VERIFY THAT THE LOADS ON THE ET/ORBITER INTERFACE, SRB BEAM, LO2 TANK AND LH2 TANK WERE WITHIN DESIGN LIMITS DURING THRUST BUILDUP, RELEASE AND ASCENT. VERIFY THAT THE LATERAL AND LONGITUDINAL LOADS ON THE ET STRUCTURE AND FEEDLINES WERE WITHIN DESIGN LIMITS DURING THRUST BUILDUP, RELEASE AND ASCENT. VERIFY THE LOADS ANALYSIS TECHNIQUES AND THE DERIVED VEHICLE LOADS. VERIFY THAT THE ET DYNAMIC RESPONSE DID NOT EXCEED THE DESIGN CRITERIA DURING THRUST BUILDUP, RELEASE AND ASCENT. VERIFY THAT THE LO2 FEEDLINE LOADS DID NOT EXCEED DESIGN CRITERIA DURING ASCENT. VERIFY THAT THE STRUCTURAL STRAINS ON THE ET/ORBITER INTERFACE HARDWARE, THE SRB BEAM, THE LH2 TANK AND THE LO2 TANK WERE WITHIN DESIGN LIMITS DURING THE TIME PERIOD ENCOMPASSING LOADING OF PROPELLANTS THROUGH FLIGHT.	COMPLETE	EXCEPT FOR MID SRB BEAM ACCEL, AC ACCELS CONTINUE TO GIVE HIGHER THAN PREDICTED G LEVELS. AFT DOME POGO PRESS ALSO CONTINUES TO GIVE HIGHER THAN PREDICTED PRESS LEVELS. NEW POGO PRESS TRANSDUCER ON FEEDLINE AGREED WITH STRAIN GAUGES AND PREDICTIONS. LOW FREQ ACCELS AND POGO PRESS TRANSDUCERS ON FLEXIBLE BASES ARE CONCLUDED TO BE IN ERROR. NO STRUCTURAL DYNAMIC PROBLEMS EXIST ON AFT LO2 DOME FOR KSC LAUNCHES
3.4.0 COMPARTMENT VENTING, VIBRATION AND ACOUSTICS		
3.4.1 NOSE CAP AND INTERTANK COMPARTMENT VENTING		
EVALUATE THE ET INTERTANK WALL PRESSURES DURING ASCENT TO VERIFY THE PREDICTED WALL PRESSURE. EVALUATE PRESSURES WITHIN THE NOSE CAP AND INTERTANK COMPARTMENTS DURING ASCENT TO VERIFY COMPARTMENT VENT PERFORMANCE.	COMPLETE	NONE
3.4.2 ET VIBROACOUSTICS		
VERIFY THAT THE ET STRUCTURE AND PROTUBERANCE VIBRATION ENVIRONMENTS AND THE ET INTERNAL ACOUSTIC ENVIRONMENTS WERE WITHIN DESIGN SPECIFICATIONS. EVALUATE EXCEEDANCES AND RECOMMEND NECESSARY ACTIONS FOR THEIR RESOLUTION.	COMPLETE	NONE

TABLE 3.1.1-1 ET OBJECTIVES AND ACCOMPLISHMENTS

OBJECTIVES	DEGREE OF ACCOMPL	DISCREPANCIES
3.5.0 THERMAL ASSESSMENT		
3.5.1 PRELAUNCH THERMAL ENVIRONMENT		
VERIFY THAT THE OVERALL ET PRELAUNCH THERMAL CONDITIONS WERE WITHIN DESIGN LIMITS AND THAT THERE WERE NO TPS DIVOTS PRIOR TO LAUNCH. SUBSTANTIATE THE CAPABILITY TO ACCURATELY PREDICT PRELAUNCH TEMPERATURE. CONFIRM THAT TPS SIZING WAS SUFFICIENT FOR PREVENTING ICE/ FROST FORMATION PRIOR TO LAUNCH. DEVELOP SUPPORTING RATIONALE IN THE EVENT OF AN ANOMALY OR MALFUNCTION.	COMPLETE	NONE
3.5.2 STRUCTURAL TEMPERATURE/TPS EVALUATION		
VERIFY THAT THE TEMPERATURES OF THE PRIMARY ET STRUCTURE REMAIN WITHIN DESIGN LIMITS THROUGHOUT FLIGHT. CONFIRM THE ADEQUACY OF THE TPS SIZING AND PERFORMANCE PREDICTIONS. SUBSTANTIATE THE CAPABILITY TO ACCURATELY MODEL AND PREDICT INFLIGHT TRANSIENT TEMPERATURES. DEVELOP SUPPORTING RATIONALE IN THE EVENT OF AN ANOMALY.	COMPLETE	NONE
3.5.3 COMPARTMENT AND COMPONENT TEMPERATURES		
EVALUATE THE THERMAL ENVIRONMENT WITHIN THE NOSE CAP AND INTERTANK COMPARTMENTS. VERIFY THAT TEMPERATURES OF ORDNANCE AND ELECTRICAL COMPONENTS REMAIN WITHIN DESIGN LIMITS.	COMPLETE	NONE
3.6.0 ELECTRONICS AND INSTRUMENTATION		
3.6.1 BUS VOLTAGE		
VERIFY THAT THE ORBITER BUS B VOLTAGE AND DFI SYSTEM BUS VOLTAGE WERE WITHIN PREDICTED LIMITS DURING THE PRELAUNCH AND ASCENT.	COMPLETE	NONE
3.6.2 INSTRUMENTATION PERFORMANCE		
EVALUATE THE PERFORMANCE OF THE ET OI AND DFI SENSORS AND MEASUREMENTS DURING FLIGHT. DETERMINE ANOMALIES OR FAILURES OF SENSORS AND OF DATA ACQUISITION EQUIPMENT AND RECOMMEND CORRECTIVE ACTION.	COMPLETE	9 MSID'S WAIVED 1 ANOMOLOUS DFI 4 ANOMOLOUS FM SENSORS

3.1.2 CONFIGURATION DESCRIPTION SUMMARY - The External Tank (ET) contains all of the subsystems and components necessary to provide fuel and oxidizer for the SSMEs. It must be environmentally secure in order to accomplish its function and structurally accommodate the variety of loads imposed on it. A schematic diagram depicting the ET and its components is shown in Figure 3.1.2-1.

The two major components of the ET are the liquid oxygen (LO2) tank and the liquid hydrogen (LH2) tank. Both tanks are constructed of aluminum alloy skins with support or stability frames as required. The primary structural attachment to the Orbiter consists of one forward and two aft connections. The primary structural attachment in each of the two SRBs also consists of one forward and two aft connections.

Spray-on Foam Insulation (SOFI) is applied to the complete outer surface of the ET, including the sidewalls and the bulkheads. A lightweight ablator is applied to selected areas, such as the attachment structures where shock impingement causes increased heating. When the ET is fully loaded, it contains approximately 1,500,000 pounds of usable propellant. The LH2 tank volume is 53,000 cubic feet and the LO2 tank volume is 19,500 cubic feet. These volumes include a 3% ullage provision.

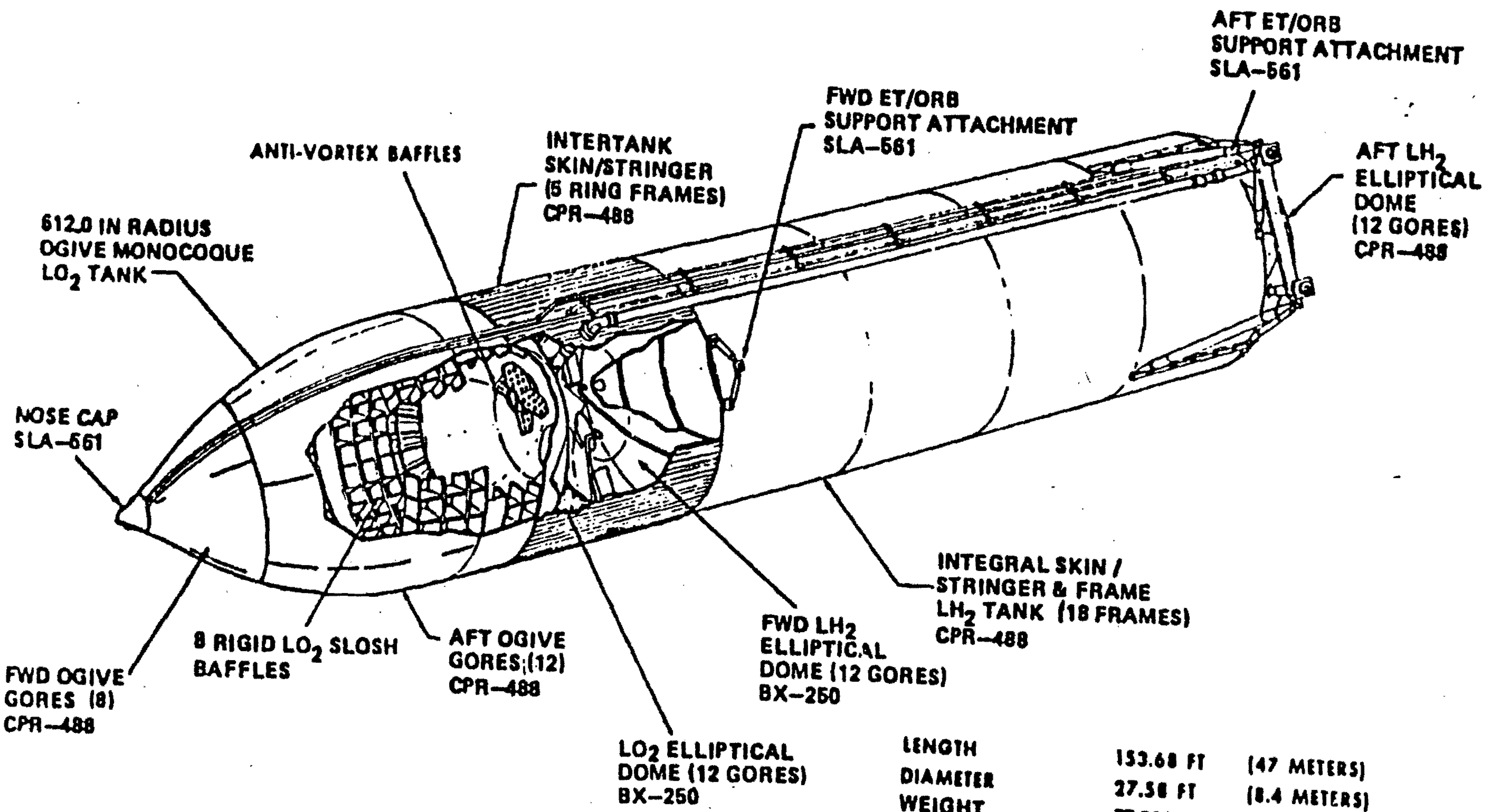
ET-4 peculiar instrumentation included the addition of:

(1) 2 DC accels on the SRB beam end and middle respectively
(2) 2 AC accels on the SRB beam end and middle respectively
(3) 4 radial and 2 tangential strain gauges on aft dome
(4) 1 additional AC accel on aft dome
(5) 1 POGO pressure transducer on LO2 feedline inside I/T

The measurements were added to provide additional data in areas that required additional analysis.

The ID number of the fourth ET is CEI-T01M2BA - S/N 0000004.

3.1.3 FAILURES, ANOMALIES AND RECOMMENDED ACTION - There were several instrumentation anomalies associated with the ET DFI during STS-4 and none associated with the OI. Tables 3.6.2-1 through 3.6.2-5 in Section 3.6.0 "Electronics and Instrumentation" present the total instrumentation status for the STS-4 External Tank. including squawked data. There were no ET failures or problems. Figure 3.1.2-2 presents a formal closeout of MSFC STS-1 Anomaly STS-0016 which was resolved based upon STS-4 data and laboratory tests.



LENGTH	153.68 FT	(47 METERS)
DIAMETER	27.58 FT	(8.4 METERS)
WEIGHT	77,000 LBS	(35,000 KILOGRAMS)
PROPELLANT	1.56M LBS	(706,000 KILOGRAMS)

FIGURE 3.1.2-1 SPACE SHUTTLE EXTERNAL TANK

FLIGHT TEST PROBLEM REPORT   NO. MSFC-1

Statement of problem:

High ET LOX Tank Bulkhead and Y-Ring Oscillatory Loads (MSFC STS-1 Anomaly STS-0016)

Discussion: Higher oscillatory pressures than expected were indicated by flight and calculated data on the LOX tank aft bulkhead (dome) on STS-1, STS-2, and STS-3 at liftoff. These pressures did not exceed design loads. However, there was concern that an increase in these pressures on later flights could exceed LO_2 tank proof tests at the dome and Y-ring between the LO_2 tank aft dome and barrel.

On STS-2 strain gauges were added to the aft dome and the range of an accelerometer was increased to prevent its saturation during liftoff. Evaluation of STS-2 strain gauge data converted to pressures matched flight predictions. However, STS-2 accelerometer data (like STS-1) indicated approximately four times predicted data. Subsequent ground tests disclosed that accelerometers were not properly grounded and were sensitive to static-charged items near them. As a result grounded STS-3 accelerometers showed a 60 percent decrease in amplitude compared to STS-1 and -2. However, STS-3 accelerometer and pressure data were still inconsistent.

Required date for resolution:

None

Personnel assigned: ED22/T. Bullock 8-25-82

Action Progress: Additional instrumentation was added for STS-4 to determine the accuracy of existing measurements: AC and DC accelerometers on crossbeam; AC accelerometer and six strain gauges on LO_2 aft dome; pressure transducer replacing temperature sensor in LOX line; and sample rate increase for two existing strain gauges from 10 to 50 sps. Dynamic pressure gauge testing was performed. Based on results from the additional instrumentation and from pressure gauge tests, it appears that the dome oscillatory pressures at liftoff are from ±5 to ±7 psi. This dynamic pressure was determined from the new pressure transducer in the LOX inlet line about 15 inches below tank bottom and from strain gauges on the dome.

Effect on subsequent missions:

None on KSC launches

Conclusions: The pressures measured by the original (STS-1, -2, -3, and -4) dome gauges showed pressures much higher than expected. Those higher pressure levels seem to reflect a phantom magnification because of the location of the original dome gauge on a structure experiencing high strains. The false readings were verified in the dynamic flexible bottom container tests. It is, therefore, concluded that no LOX dome pressure anomaly exists for KSC liftoff transients. Also, the measured data now verifies the predictions.

Corrective action:

None required. For more reliable flight data, the piezo-type POGO pressure transducer on the LOX tank dome will be replaced with a pot-type and accelerometers will be grounded better starting with STS-5 heavy-weight ET.

FIGURE 3.1.2-2 MSFC STS-1 ANOMALY STS-0016 CLOSEOUT

3.2.0 PROPELLANT SLOSH DAMPING - The flight dynamic parameters did not show enough oscillatory activity in the LO2 slosh frequency range to provide a means of determining any value for the slosh damping. The LO2 predicted slosh mass and dynamic characteristics using the theoretical model and the STS-4 flight values for the liquid level and vehicle accelerations are shown in Figure 3.2.0-1.

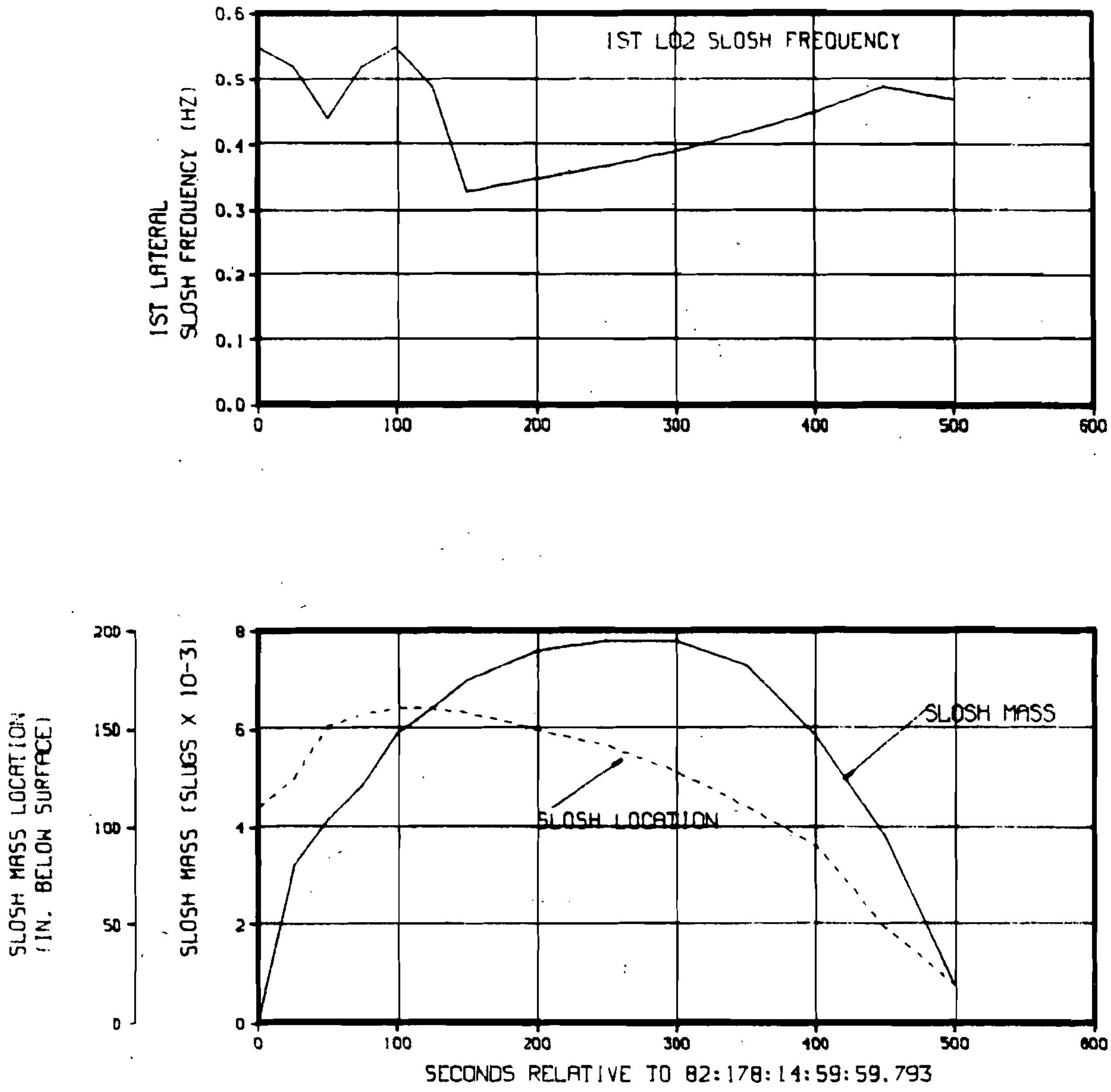


FIGURE 3.2.0-1 SLOSH MASS AND DYNAMIC CHARACTERISTICS

This flight confirms that the damping fell within the required range, as predicted, and was adequate for the maneuvers and environmental conditions experienced. The LO2 level sensors located in the baffled region of the tank were uncovered cleanly, further indicating the low level of any slosh oscillations.

3.3.0 STRUCTURE AND LOADS

ET ASCENT LOADS VERIFICATION - Structure loads measurements for the ET assessment include:

28 strain gauges ET/ORB - 7 struts
19 strain gauges on LH2 tank (Sta. 1554)
6 strain gauges on ET crossbeam
4 strain gauges on LO2 aft dome
4 strain gauges on LO2 feedline brackets
4 accelerometers on LO2 dome
3 accelerometers on LH2 tank bottom
1 dynamic pressure gauge on LO2 dome
1 dynamic pressure gauge on LH2 tank bottom
3 ET nose accelerometers
3 LO2 feedline aft hardpoint accelerometers
3 LO2 feedline upper section accelerometers
3 dynamic pressure gauges on LO2 feedline
1 mid SRB crossbeam accelerometer
1 mid LO2 feedline accelerometer
6 accelerometers on ET crossbeam
1 dynamic pressure gauge on LO2 feedline

In general, the approach used for the loads assessment is as follows: The strains were converted to loads by the product of cross sectional area, modulus of elasticity and the delta strain reading for the event being analyzed. This delta measured load then is added to the predicted initial condition load and the combination results in a total or net load. This procedure is followed because the gauges reflect a biased strain prior to ignition of the SSME's which is not a true strain of the structure. The low frequency accelerometers and pressure gauges are dynamic measurements and the response peaks were assessed. The LO2 and LH2 aft dome pressure were added to the static head and ullage pressure to determine a total pressure. From the measured strut strains (ET/Orbiter), the orthogonal loads were calculated for the interface structure.

Strain data from the SRB crossbeam were used to determine the forward ET/SRB attach loads.

The primary interest in the loads evaluation was how well the predicted and STS-1, STS-2, and STS-3 measured loads compared with the STS-4 measured loads for their respective burn times. Therefore, this assessment concentrates in these areas. Rockwell International provided predictions on all ET/Orbiter strut and ET/SRB strut loads for pre-ignition, SSME buildup, liftoff and ascent conditions. MPTA data were used as comparisons for accelerations and pressures.

Locations of Orbiter and ET attachment strut (P1 through P7) are shown in Figure 3.3.0-1. Each of these struts were instrumented with four strain gauges.

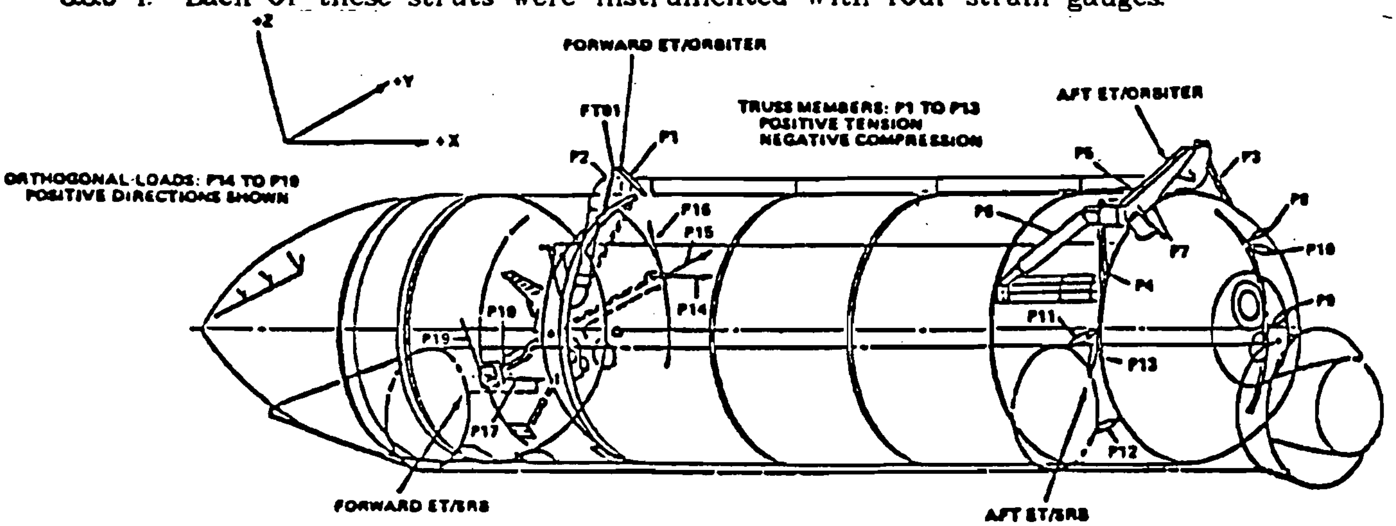


FIGURE 3.3.0-1 ET ATTACH STRUTS

ET/ORBITER STRUT LOADS - Loads on the Orbiter to ET attachment struts have been assessed for the following events:

1. SSME Thrust Buildup
2. Liftoff
3. Maximum Dynamic Pressure (High Q)
4. Maximum SRB Acceleration (BA)
5. SRB Tailoff (Pre-SRB Staging)
6. SRB Post-staging
7. Maximum C Orbiter Burn
8. Orbiter End Burn

The predicted net loads were furnished by Rockwell International/Downey and JSC/Houston. SSME thrust buildup and liftoff were based on zero wind and no parameter dispersions. Predicted loads for maximum dynamic pressure conditions are based upon L + 15 minute nominal measured winds. Maximum SRB acceleration through Orbiter end burn load predictions are based on 3 sigma dispersed loads.

Measured net loads were calculated by averaging the four strain gauges for each strut (except during buildup and liftoff), then multiplying by a modulus of elasticity E = 10.5x10E6 psi and the cross sectional areas for the appropriate strut. Design limit loads were obtained from the Rockwell International Loads Data Book. The design limit loads reflect the results of combining -3C and -3D loads.

A comparison of STS-1 measured/STS-2 measured/STS-3 measured/STS-4 measured, predicted, design loads are shown in Tables 3.3.0-1 through 3.3.0-8. STS-1, STS-2, STS-3, and STS-4 loads show good agreement, especially STS-2, STS-3, and STS-4 results. A high angle of attack was flown during the max q region, which resulted in lower loads on the forward struts (P1 and P2). Figure 3.3.0-2 is a typical strain gauge plot with the tension and compression limit loads superimposed. Member loads versus time are shown in Figure 3.3.0-3 through 3.3.0-9. Baseline aerodynamic data and aerodynamic data from the previous flights were the basis for the predicted and measured data, respectively.

TABLE 3.3.0-1 ET STRUT LOADS -SSME BUILDUP

	PREDICTED* NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-45	-52	-53	-49	-47	-131
P2	-45	-50	-46	-45	-48	-131
P3	168	171	171	162	157	+476
P4	168	176	157	160	161	+490
P5	-518	-560	-532	-538	-541	-834
P6	-518	-542	-508	-530	-533	-834
P7	-8	8	-5	10	8	+177

* PREDICTED LOADS BASED ON NO WIND AND DISPERSION

TABLE 3.3.0-2 ET STRUT LOADS -LIFTOFF

	PREDICTED* NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-58	-68	-56	-52	-50	-131
P2	-58	-65	-48	-46	-47	-131
P3	183	180	156	153	145	+476
P4	183	192	149	155	166	+490
P5	-535	-551	-518	-516	-504	-834
P6	-535	-537	-492	-514	-495	-834
P7	-28	7	1	10	8	+177

* PREDICTED LOADS BASED ON NO WIND AND DISPERSION

TABLE 3.3.0-3 ET STRUT LOADS -MAX DYNAMIC PRESSURE

	PREDICTED* NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-32	-40	-34	-45	-19	-131
P2	-25	-36	-42	-31	-21	-131
P3	250	219	241	224	255	+476
P4	275	245	191	272	272**	+490
P5	-425	-504	-481	-447	-460	-834
P6	-420	-486	-484	-456	-466	-834
P7	-20	-21	-7	-20	-10	-173

* PREDICTED LOADS BASED ON L + 15 MIN. WINDS
** DISPERSED PREDICTED LOAD AT LAUNCH > 90% DESIGN

TABLE 3.3.0-4 ET STRUT LOADS -MAX SRB ACCELERATION (BA)

	PREDICTED* NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-20	-30	-13	-31	-25	-131
P2	-19	-28	-19	-22	-26	-131
P3	129	135	201	117	137	+476
P4	131	154	184	135	182	+490
P5	-480	-473	-414	-458	-397	-834
P6	-481	-477	-418	-464	-412	-834
P7	-1	3	8	6	2	+177

* PREDICTED LOADS BASED ON 3 SIGMA DISPERSION

TABLE 3.3.0-5 ET STRUT LOADS - PRE-SRB STAGING

	PREDICTED* NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-50	-53	-49	-50	-49	-131
P2	-50	-51	-48	-45	-52	-131
P3	217	244	218	214	228	+476
P4	217	252	191	212	216	+490
P5	-735	-722	-724	-736	-736	-834
P6	-735	-703	-711	-734	-712	-834
P7	0	-12	10	-32	-18	-173

* PREDICTED LOADS BASED ON 3 SIGMA DISPERSION

TABLE 3.3.0-6 ET STRUT LOADS - POST SRB STAGING

	PREDICTED* NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-59	-55	-57	-59	-56	-131
P2	-59	-57	-55	-54	-58	-131
P3	261	253	261	239	253	+476
P4	261	261	245	253	251	+490
P5	-742	758	-729	-718	-721	-834
P6	-742	735	-713	-720	-706	-834
P7	0	-9	-3	3	-2	-173

* PREDICTED LOADS BASED ON 3 SIGMA DISPERSION

TABLE 3.3.0-7 ET STRUT LOADS - ORBITER MAX BURN

	PREDICTED NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	-5	-11	-18	-17	-13	-131
P2	-5	-10	-12	-13	-15	-131
P3	127	153	168	141	145	+476
P4	127	153	152	151	131	+490
P5	-449	-442	-480	-474	-476	-834
P6	-449	-435	-492	-480	-469	-834
P7	0	3	1	7	7	+177

TABLE 3.3.0-8 ET STRUT LOADS - ORBITER END BURN

	PREDICTED NET LOAD (KIPS)	MEASURED NET LOAD STS-1 (KIPS)	STS-2 (KIPS)	STS-3 (KIPS)	STS-4 (KIPS)	DESIGN LIMIT LOAD (KIPS)
P1	12	8	7	12	8	+146
P2	12	8	8	10	8	+146
P3	44	62	62	40	45	+476
P4	44	63	48	52	63	+490
P5	-178	-148	-181	-170	-128	-834
P6	-178	-157	-181	-179	-153	-834
P7	0	2	1	7	7	+177

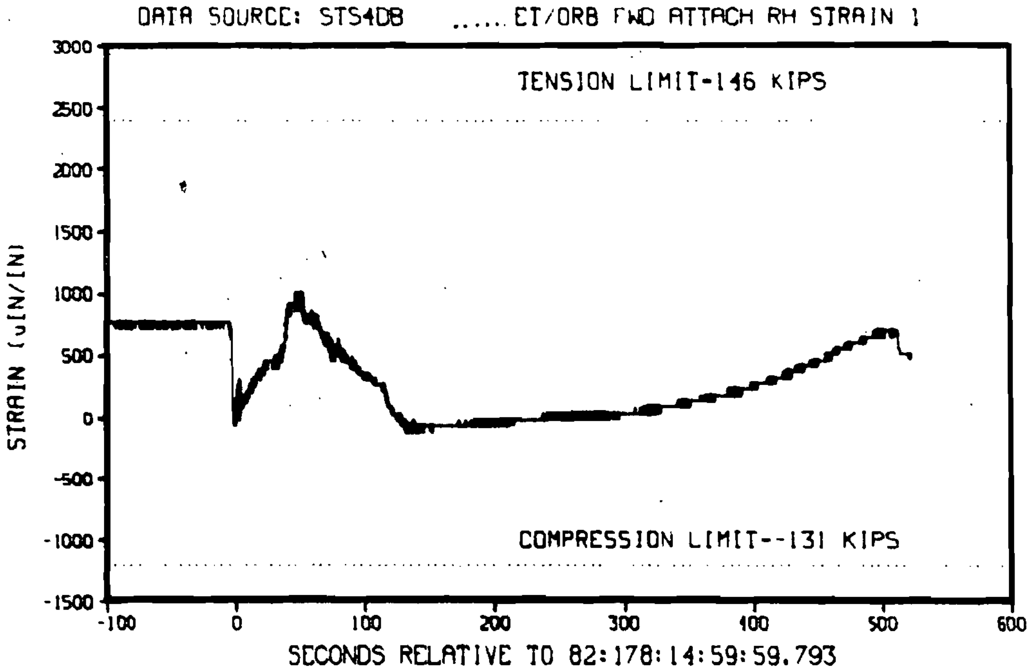


FIGURE 3.3.0-2 TYPICAL STRAIN GAGE PLOT

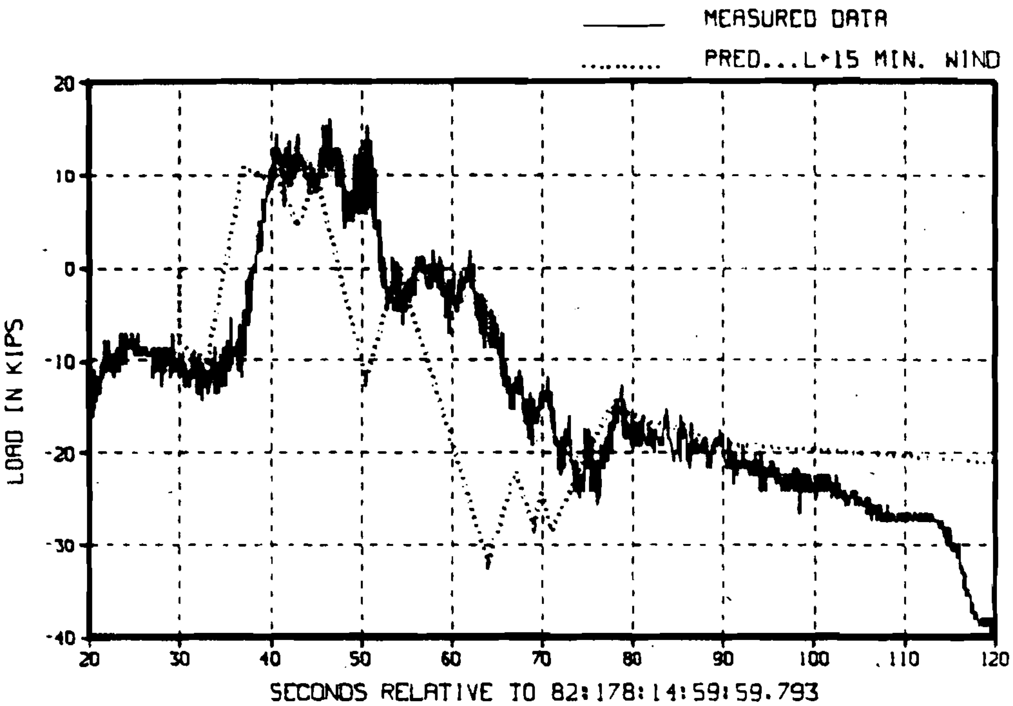


FIGURE 3.3.0-3 STRUT LOAD P1 VS TIME

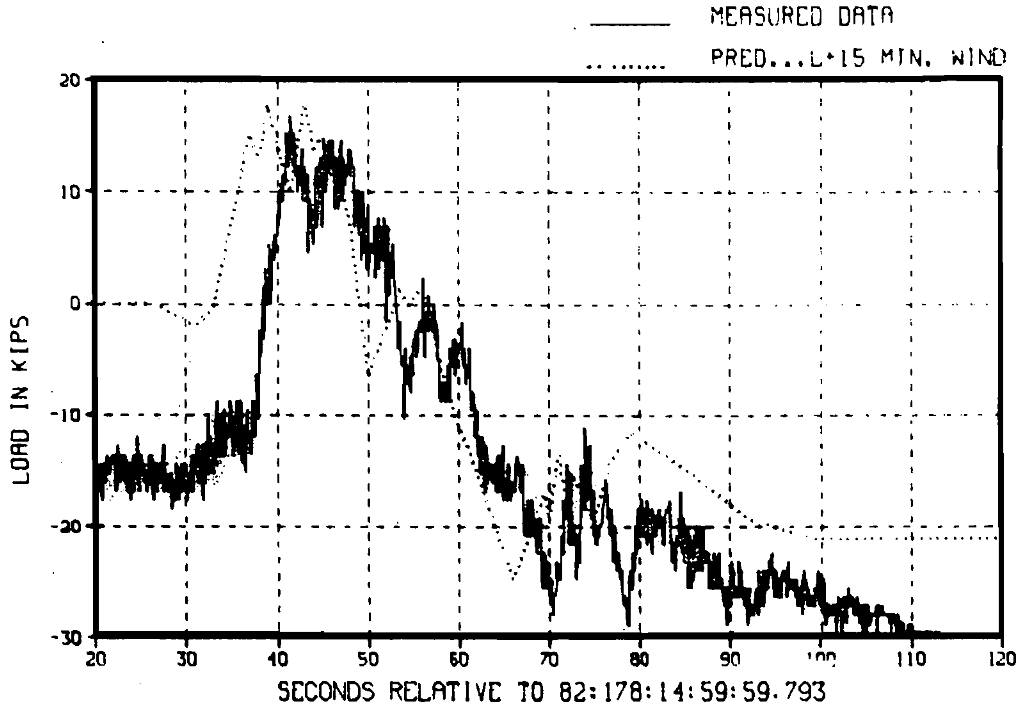


FIGURE 3.3.0-4 STRUT LOAD P2 VS TIME

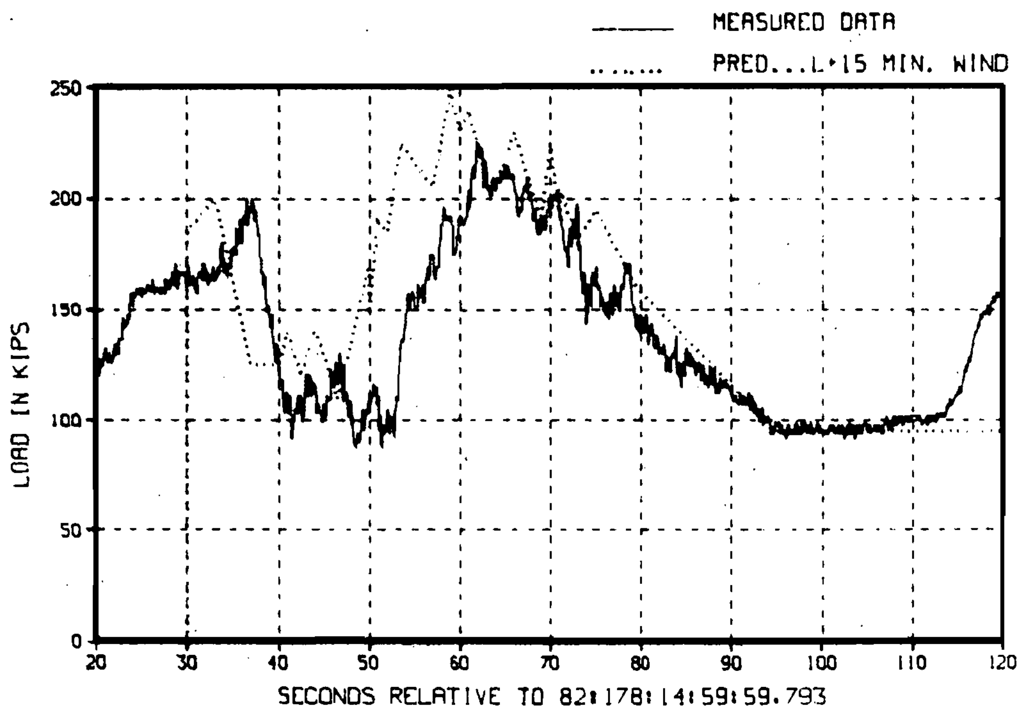


FIGURE 3.3.0-5 STRUT LOAD P3 VS TIME

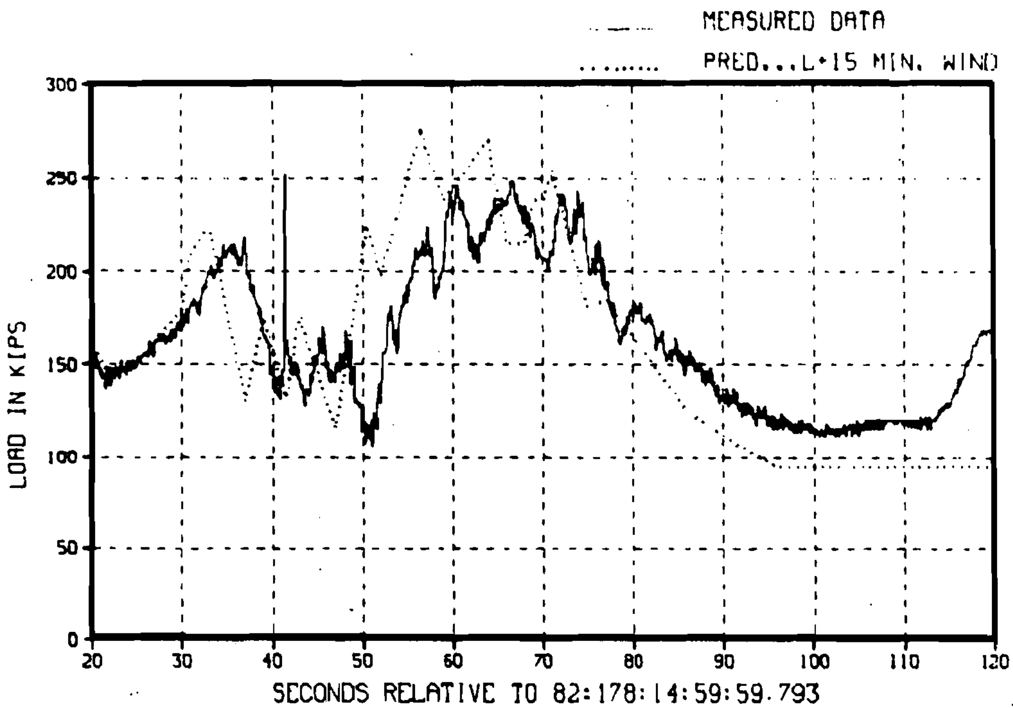


FIGURE 3.3.0-6 STRUT LOAD P4 VS TIME

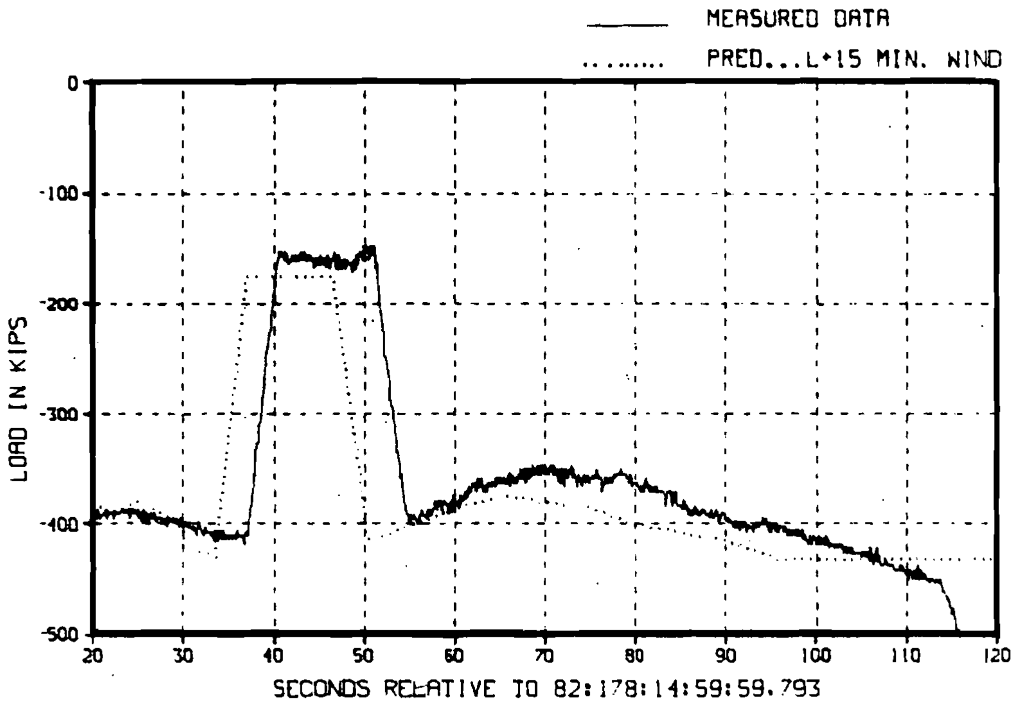


FIGURE 3.3.0-7 STRUT LOAD P5 VS TIME

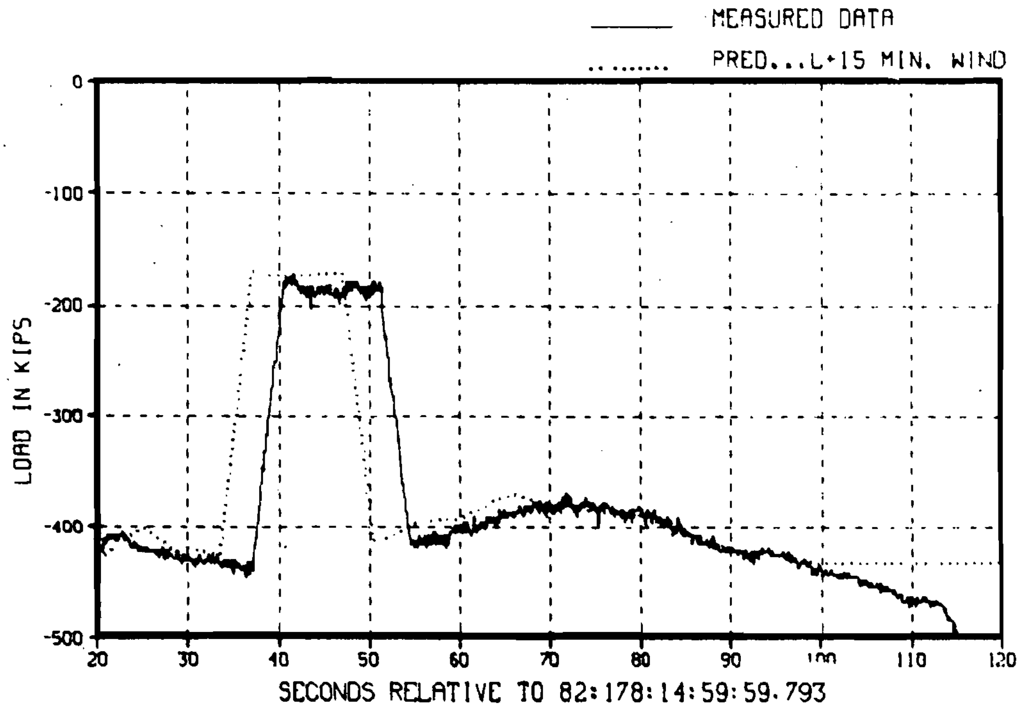


FIGURE 3.3.0-8 STRUT LOAD P6 VS TIME

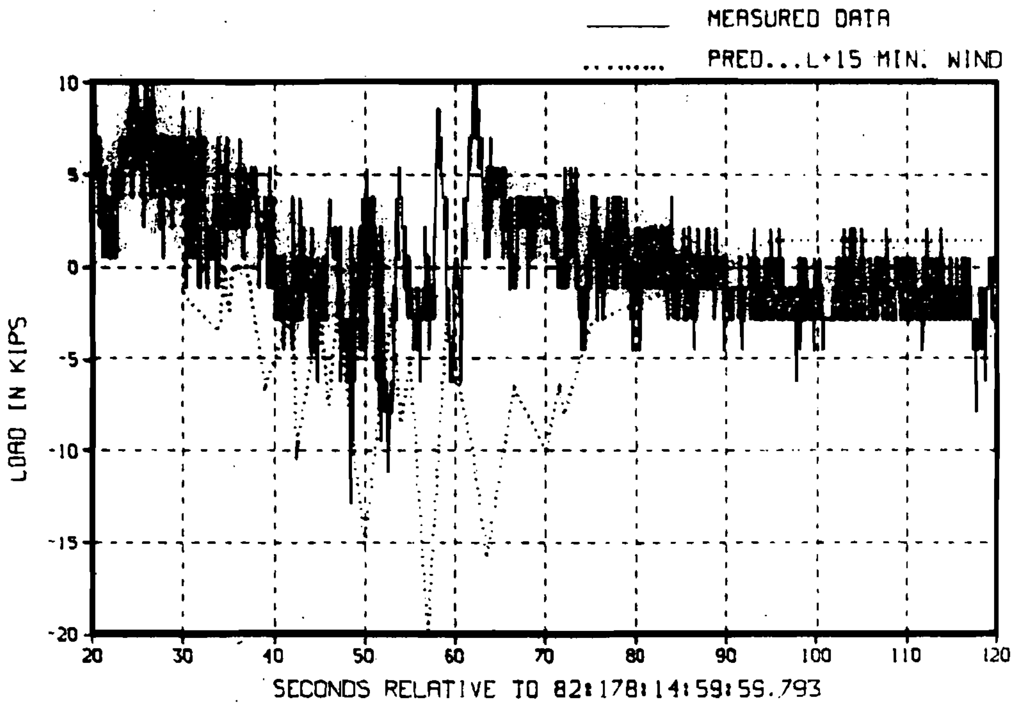


FIGURE 3.3.0-9 STRUT LOAD P7 VS TIME

AFT ET/SRB STRUT LOADS - The aft SRB to ET strut loads (P8 -- P13) are usually discussed in Section 2.5.0 (SRB Structure and Loads), but due to the loss of the SRB's there are no data for STS-4.

ET/ORBITER INTERFACE AND STRUT LOADS - The strains measured by the gauges on the ET/Orbiter interface hardware and the LO2 feedline support brackets are used within a computer program (FLYTAN) written by MMC/MAF to evaluate the ET/Orbiter interface loads (FT01 through FT08) and the interface hardware strut loads (P1 through P7).

The indicated strain is adjusted for Orbiter weight and LO2 feedline loads to give a true strain for each gauge. The strains are averaged for each strut and converted to strut (P) loads by multiplying with cross-sectional areas and modulus of elasticity. The true strain is then corrected for LO2 feedline fluid and dynamic loads, LO2 feedline weight and used with procedures described in MMC ET-004 Calibration Report (826-2186-04) to calculate the FTO loads. Results of strut (P) and FTO loads calculated using measurements at 10 sps are shown in Figure 3.3.0-10 through Figure 3.3.0-23 using a reference time 1982:178:14:59:59.793 GMT.

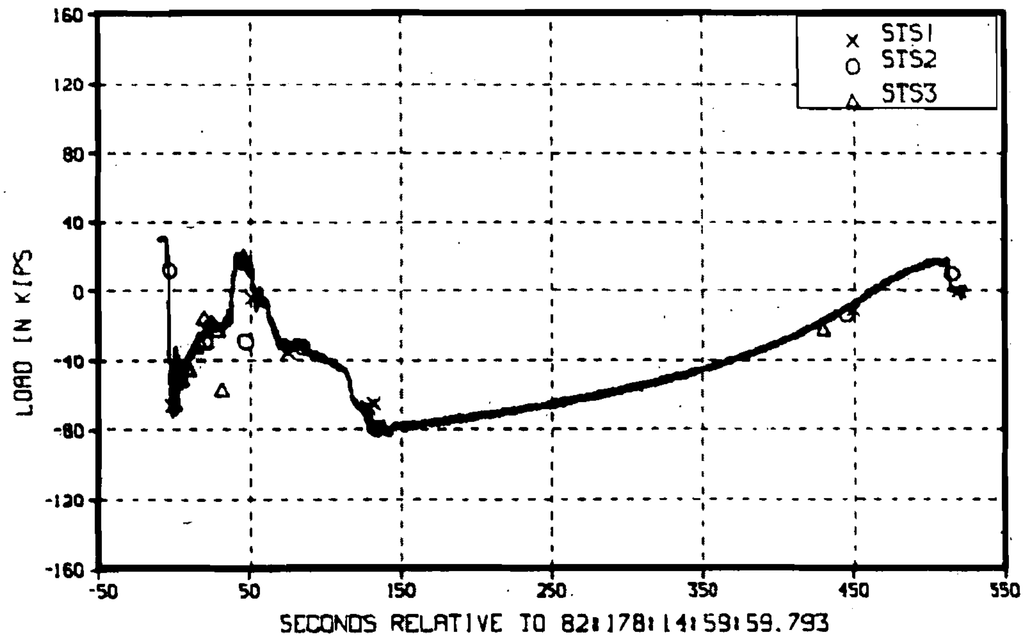


FIGURE 3.3.0-10 ET/ORB I/F LOAD (FT01)

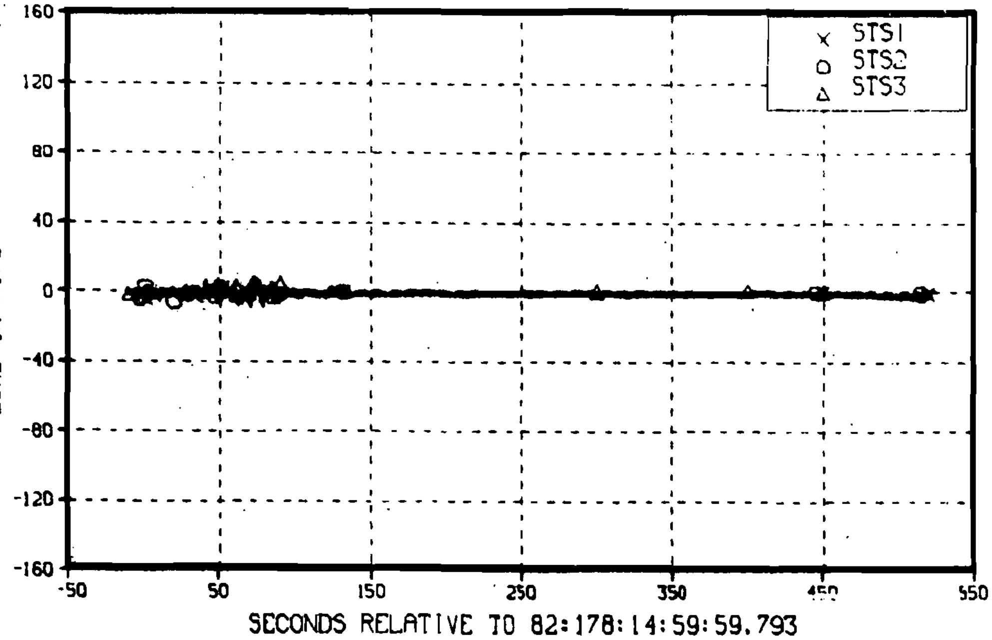


FIGURE 3.3.0-11 ET/ORB I/F LOAD (FT02)

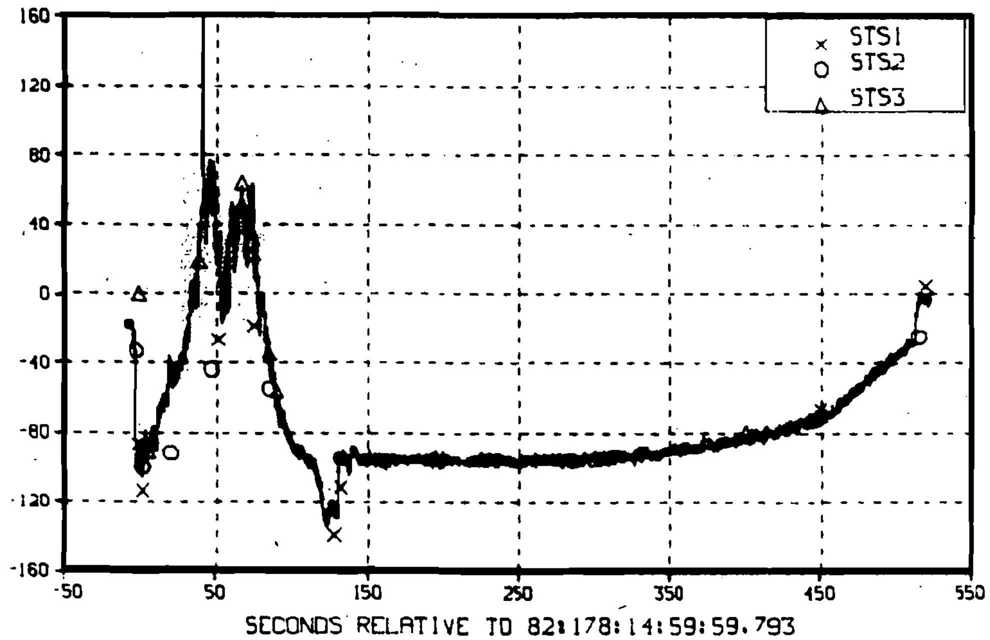


FIGURE 3.3.0-12 ET/ORB I/F LOAD (FT03)

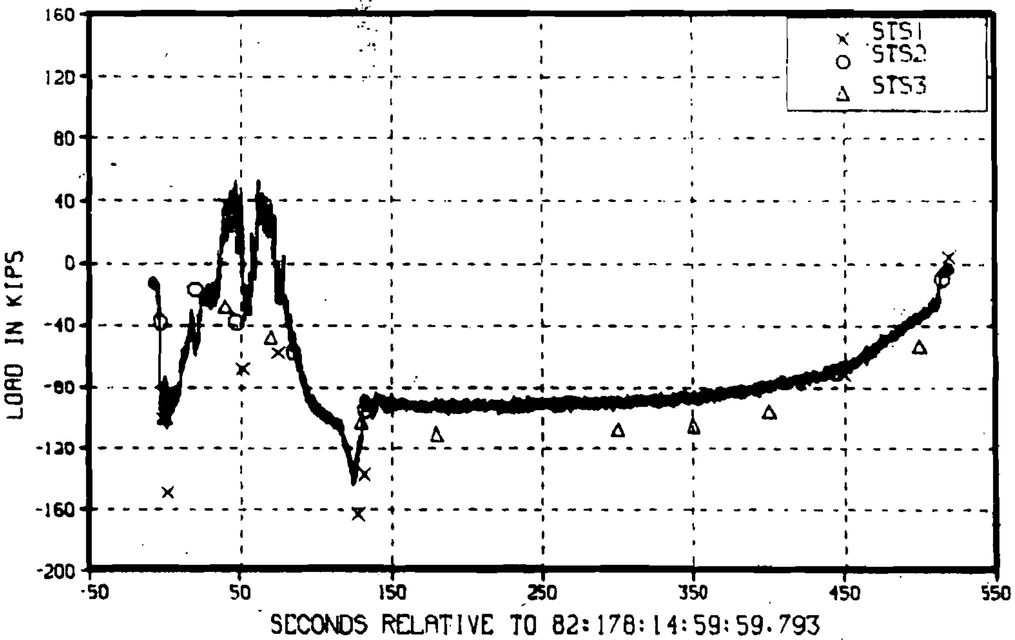


FIGURE 3.3.0-13 ET/ORB I/F LOAD (FT04)

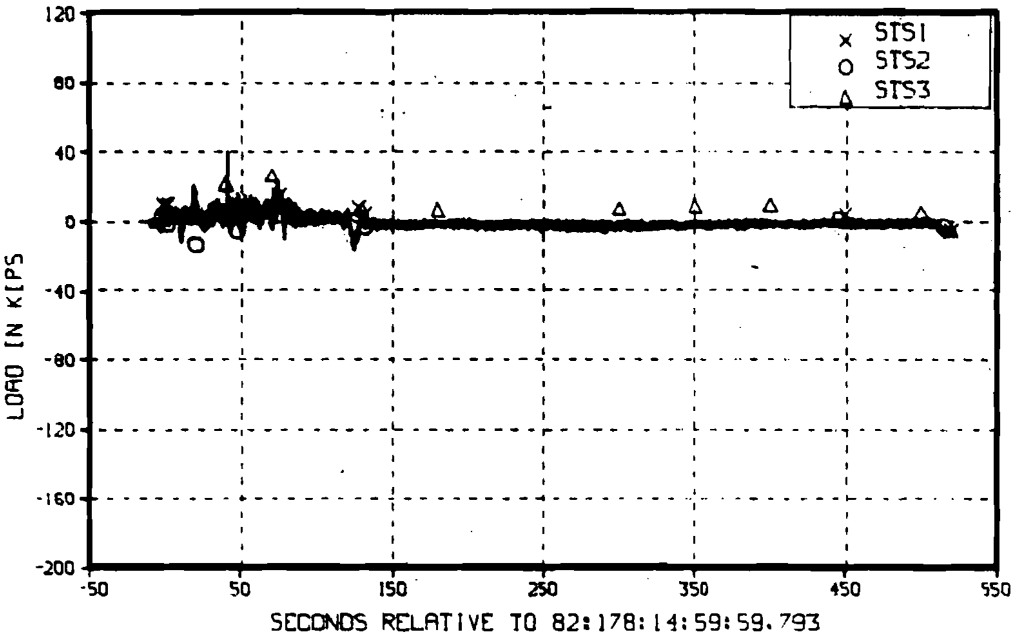


FIGURE 3.3.0-14 ET/ORB I/F LOAD (FT05)

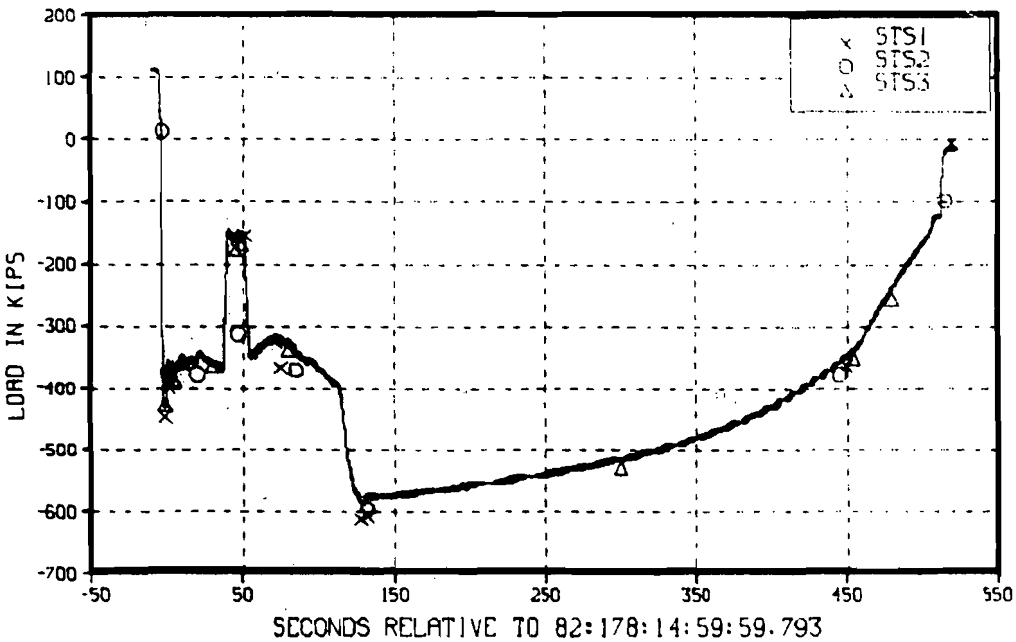


FIGURE 3.3.0-15 ET/ORB I/F LOAD (FT07)

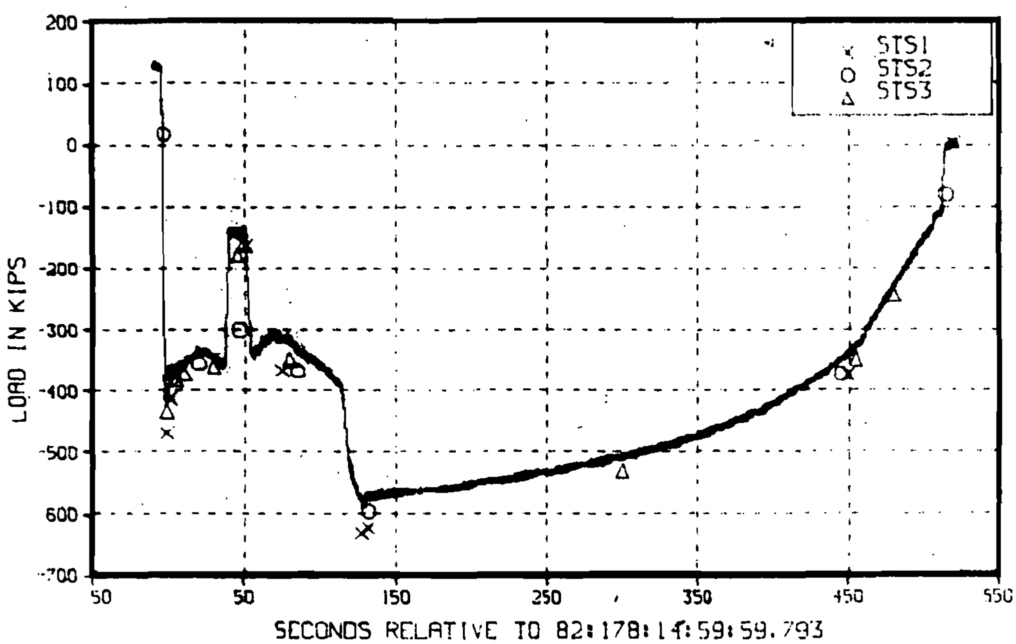


FIGURE 3.3.0-16 ET/ORB I/F LOAD (FT08)

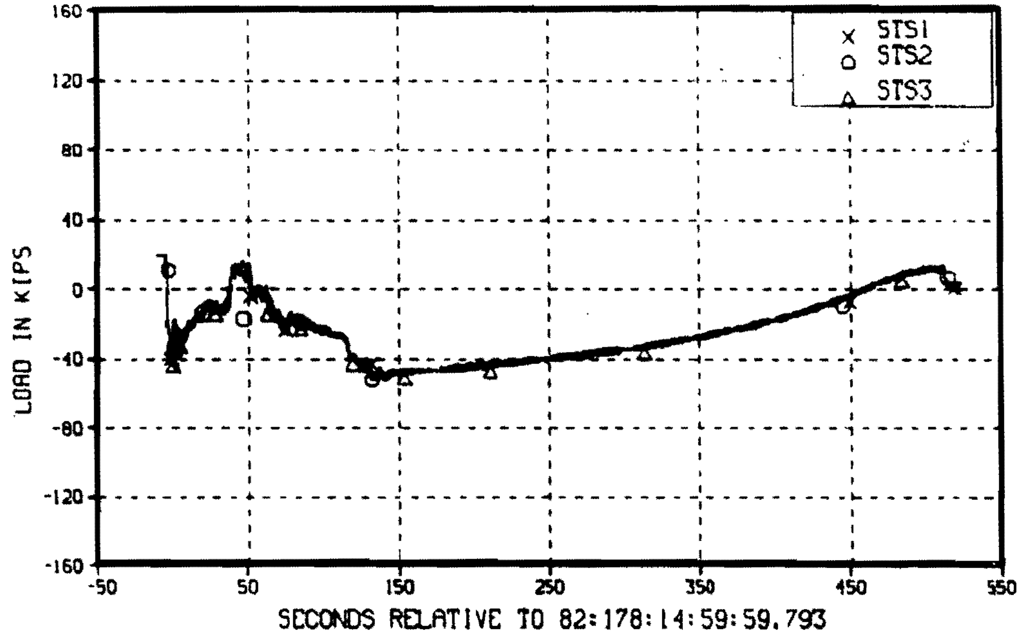


FIGURE 3.3.0-17 STRUT LOAD P1 VS. TIME

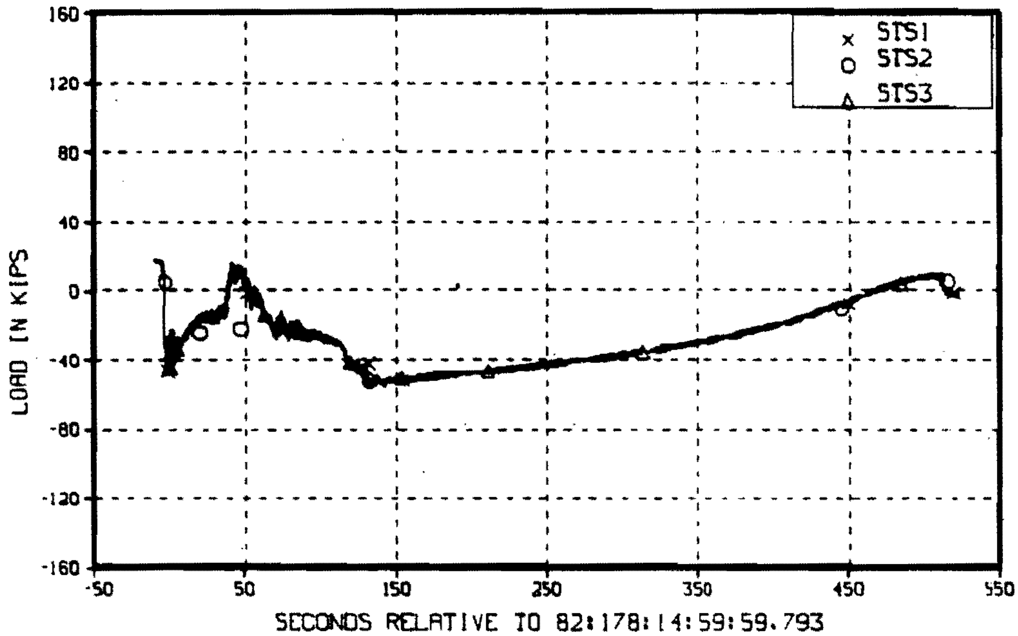


FIGURE 3.3.0.-18 STRUT LOAD P2 VS. TIME

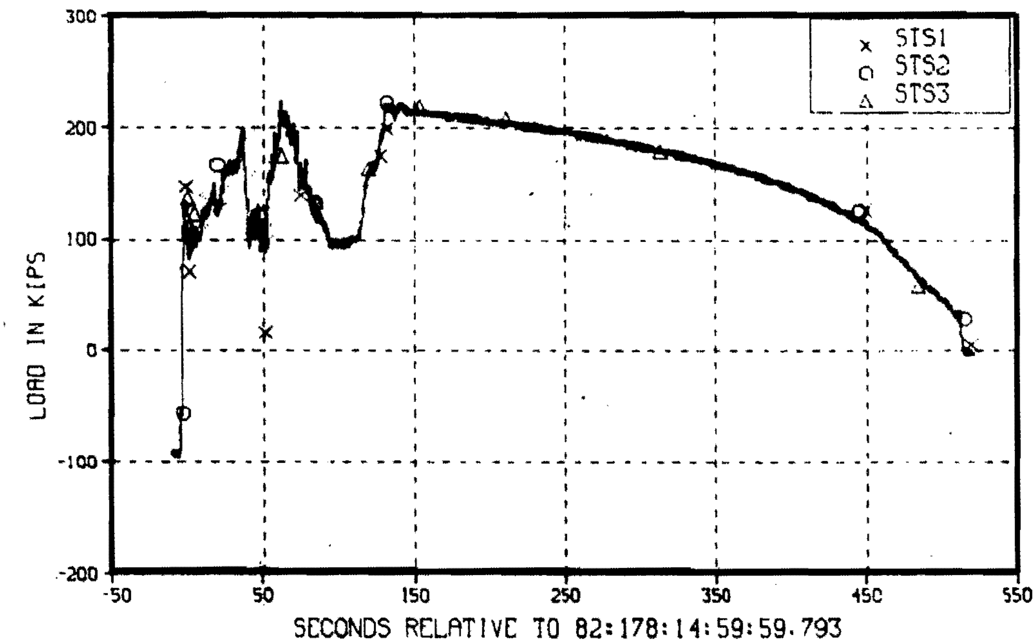


FIGURE 3.3.0-19 STRUT LOAD P3 VS. TIME

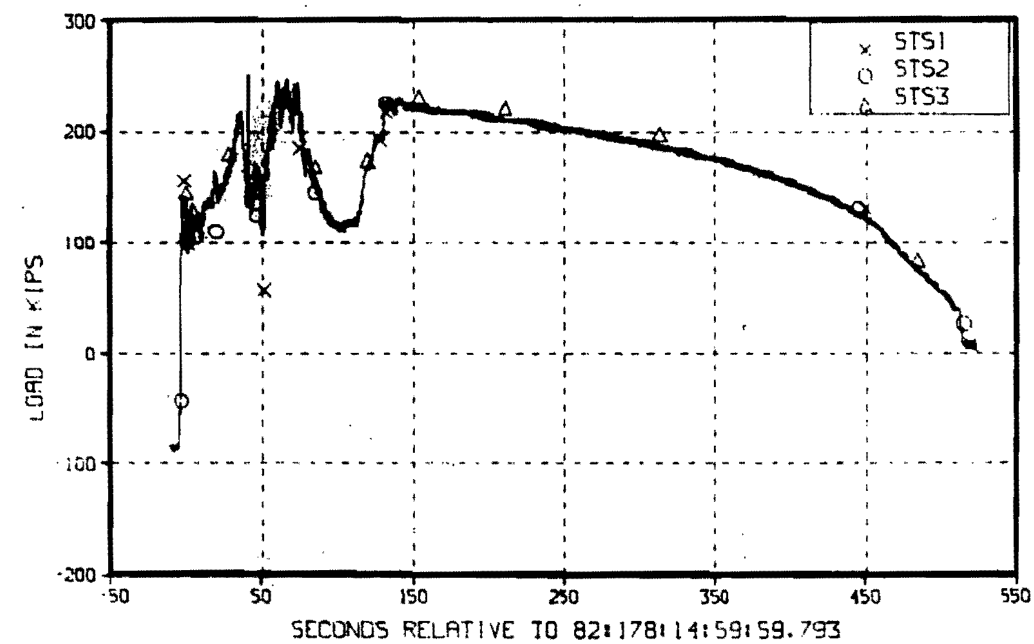


FIGURE 3.3.0-20 STRUT LOAD P4 VS. TIME

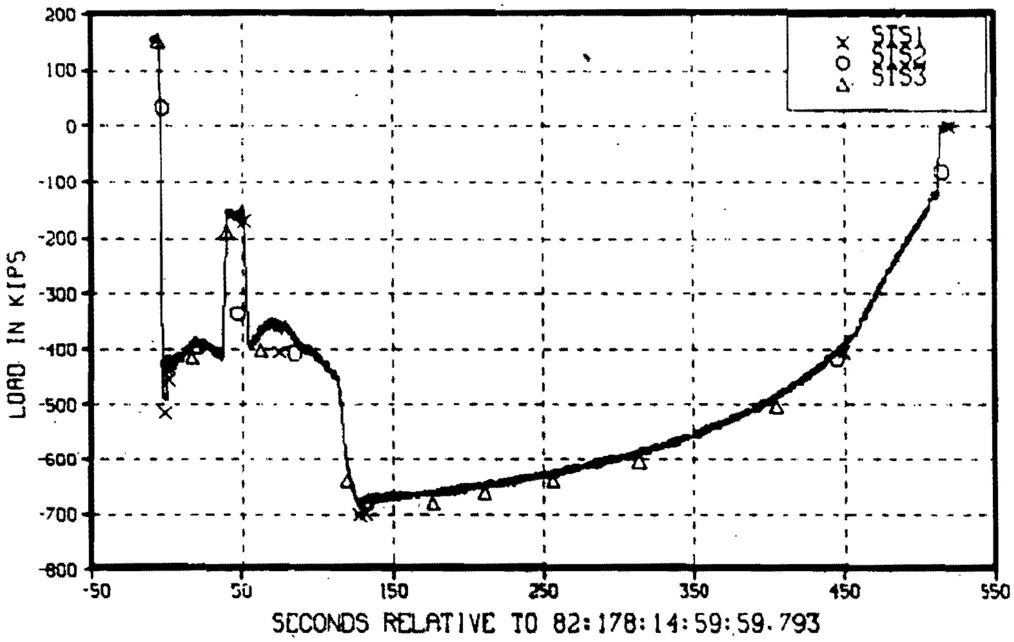


FIGURE 3.3.0-21 STRUT LOAD P5 VS. TIME

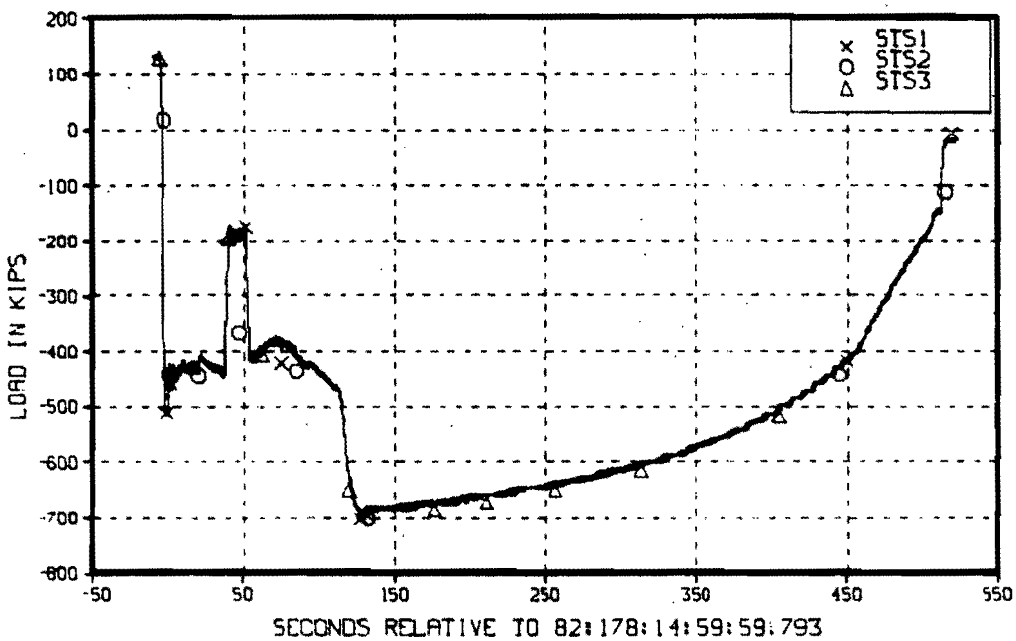


FIGURE 3.3.0-22 STRUT LOAD P6 VS. TIME

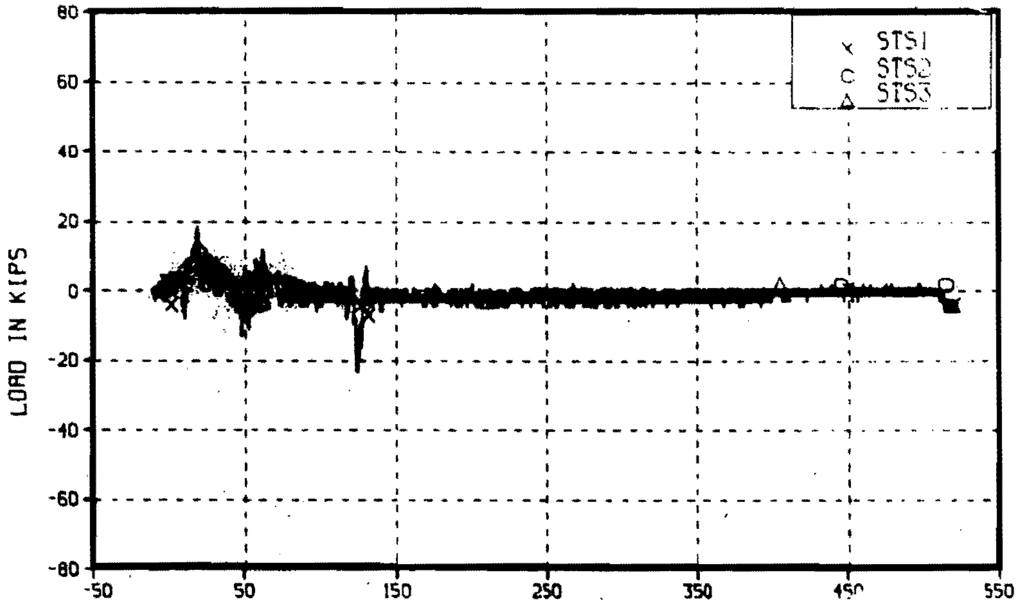


FIGURE 3.3.0-23 STRUT LOAD P7 VS. TIME

TANK PRESSURES AND ET ACCELERATIONS - A summary of the LO2 and LH2 tank bottom low frequency oscillatory pressures are contained in Table 3.3.0-9. Peak levels and the frequency of oscillation are shown for six events from SSME ignition through SRB post separation. Since these are dynamic gauges, no static or ullage pressures are presented. The LO2 feedline oscillatory pressures are depicted in Table 3.3.0-10. Tables 3.3.0-11 through 3.3.0-15 show the low frequency acceleration data. These gauges are located on the ET nose, LO2 tank bottom, LO2 feedline, and LH2 tank bottom. These accelerations were obtained from tri-axis accelerometer data and are described in the X, Y, and Z directions.

The MPT predicted data are shown as a comparison to the measured levels and frequencies. No rigid body accelerations are included. The A.C. accelerometer located on the aft LO2 dome was retained from the STS-3 flight and two new A.C accelerometers were located on the crossbeam middle and end (Table 3.3.0-16). Table 3.3.0-17 shows three D.C. accelerometers located on the middle of the crossbeam in the normal, Y, and Z directions. One other D.C. accelerometer was located on the crossbeam end and a new pressure gauge was located in the LO2 inlet line located 15 inches below the LO2 aft dome. Table 3.3.0-18 depicts the results. A comprehensive discussion of the LO2 aft dome problem will be made in that section, but certain conclusions can be drawn; namely, that the lox frequency A.C. pressure and accelerometer measurements located on the crossbeam and LO2 aft dome are probably invalid. (See FTPR MSFC-1 in Section 3.1.)

TABLE 3.3.0-9 STS-4 ET - LO2 and LH2 TANK BOTTOM PRESSURES

	TIME (SEC)	LO2* (+/-PSI)	FREQ. (HZ)	LH2 (+/-PSI)	FREQ. (HZ)
SSME IGNITION	-4	7.0	4	3.5	4
LIFTOFF	0	21.0	4	7.0	5
SRB STEADY STATE	25	1.5	10	2.0	6
MAX Q	45	7.0	24	3.0	6
MAX G	84	4.0	31	5.0	40
POST SEPARATION	130	8.0	28	5.0	40

*THE PRIMARY PRESSURE GAUGE, WHICH IS LOCATED ON THE DOME, DOES NOT PROVIDE VALID DATA BECAUSE THE OSCILLATORY PRESSURES DO NOT CORRELATE WITH PREDICTED DATA, STRAIN GAUGES ON THE DOME, AND A PRESSURE GAUGE LOCATED IN THE LO2 LINE INLET ABOUT 15 INCHES BELOW THE TANK BOTTOM.

TABLE 3.3.0-10 STS-4 ET - LO2 FEEDLINE PRESSURES

	TIME SEC.	FORWARD +/-PSI	FREQ. HZ	MIDDLE +/-PSI	FREQ. HZ	LOWER +/-PSI	FREQ. HZ
SSME IGNITION	-2	2.3	42	11.5	3.0	0.3	36
LIFTOFF	0	2.5	30	7.5	20	0.1	36
SRB STEADY STATE	19	0.8	44	1.4	22	0.5	38
MAX Q	50	9.8	24	11.8	17	0.1	40
MAX G	84	8.0	30	8.0	26	0.5	32
POST SEPARATION	130	3.4	22	3.0	28	0.1	32

TABLE 3.3.0-11 STS-4 ET - LO2 TANK BOTTOM ACCELERATIONS

	TIME SEC.	X-ACCEL. +/-G	FREQ. HZ	Y-ACCEL. +/-G	FREQ. HZ	Z-ACCEL. +/-G	FREQ. HZ
SSME IGNITION	-4	1.1	4	0.3	4	0.3	4
LIFTOFF	0	1.4*	4	0.5	4	0.7	4
SRB STEADY STATE	25	0.4	42	0.2	42	0.2	42
MAX Q	45	0.8	46	0.2	37	0.3	30
MAX G	84	1.1	40	0.3	39	0.3	36
POST SEPARATION	130	4.1	40	0.7	40	0.7	42
MPT PREDICTED		3.5	20	1.3	20	4.0	16

*ACCELEROMETERS GROUNDED WHICH ACCOUNT FOR DECREASE FROM STS-2.

TABLE 3.3.0-12 STS-4 ET - LH2 TANK BOTTOM ACCELERATIONS

	TIME SEC.	X-ACCEL. +/-G	FREQ. HZ	Y-ACCEL. +/-G	FREQ. HZ	Z-ACCEL. +/-G	FREQ. HZ
SSME IGNITION	-4	3.0	36	0.7	32	1.9	35
LIFTOFF	0	3.1	37	0.7	32	1.0	36
SRB STEADY STATE	25	1.5	42	0.2	36	0.5	40
MAX Q	45	5.3	38	1.8	23	2.2	38
MAX G	84	3.0	36	1.5	36	2.8	35
POST SEPARATION	130	5.0	40	1.0	39	1.5	42
MPT PREDICTED		6.0	40	1.8	40	2.5	40

TABLE 3.3.0-13 STS-4 ET - NOSE ACCELERATIONS

	TIME	X-ACCEL. +/-G	FREQ. HZ	Y-ACCEL. +/-G	FREQ. HZ	Z-ACCEL. +/-G	FREQ. HZ
LIFTOFF	0	0.4	50	0.4	49	0.8	4
SSME IGNITION	-4	0.8	50	0.8	50	0.8	52
SRB STEADY STATE	25	0.8	37	1.5	33	0.8	42
MAX Q	45	0.2	60	0.7	48	1.0	51
MAX G	85	0.4	50	0.8	40	0.8	42
POST SEPARATION	130	1.1	50	1.0	35	1.6	42
MPT PREDICTED		1.5	40	1.5	40	1.5	40

TABLE 3.3.0-14 STS-4 ET - LO2 FEEDLINE AFT HARDPOINT ACCELERATIONS

	TIME SEC.	X-ACCEL. +/-G	FREQ. HZ	Y-ACCEL. +/-G	FREQ. HZ	Z-ACCEL. +/-G	FREQ. HZ
SSME IGNITION	-4	0.9	34	0.8	35	1.0	33
LIFTOFF	0	0.8	34	0.9	39	0.5	45
SRB STEADY STATE	25	0.4	34	0.6	39	0.3	38
MAX Q	45	10	37	2.0	31	1.2	36
MAX G	84	1.2	36	2.0	33	1.2	30
POST SEPARATION	130	0.6	39	0.9	37	0.5	36
MPT PREDICTED		1.8	40	1.5	40	1.3	30

TABLE 3.3.0-15 STS-4 ET - LO2 FEEDLINE UPPER SECTION

	TIME SEC.	LONG-ACC. +/-G	FREQ. HZ	TANG.-ACC. +/-G	FREQ. HZ	NORM-ACC. +/-G	FREQ. HZ
SSME IGNITION	-4	0.8	52	DELETED		1.0	42
LIFTOFF	0	0.8	4			0.8	43
SRB STEADY STATE	25	0.8	42			0.5	40
MAX Q	45	1.0	51			1.1	42
MAX G	84	0.8	42			1.8	30
POST SEPARATION	130	1.6	42			2.1	37
MPT PREDICTED		1.0	40	1.2	40	1.4	40

TABLE 3.3.0-16 STS-4 ET - CROSSBEAM & LO2 AFT DOME A.C. ACCELEROMETERS

	TIME	CROSSBEAM		CROSSBEAM		LO2 AFT	
		FREQ	END *1	FREQ	MIDDLE *1	FREQ	DOME
		+/-G	HZ	+/-G	HZ	+/-G	HZ
SSME IGNITION	-2	0.5	42	1.6	46	0.7	50
LIFTOFF	1	0.8	42	3.6	46	2.0	4
SRB STEADY STATE	23	0.3	28	0.8	42	0.4	51
MAX Q	50	0.6	28	2.1	44	1.0	40
MAX G	88	0.9	33	2.7	41	0.8	38
POST SEPARATION	130	1.8	42	3.4	42	1.5	36

TABLE 3.3.0-17 STS-4 ET - CROSSBEAM MIDDLE #2 D.C. ACCELEROMETERS

	TIME	X-AXIS +/-G	FREQ. HZ	Y-AXIS +/-G	FREQ. HZ	Z-AXIS +/-G	FREQ. HZ
SSME IGNITION	-2	0.3	34	0.05	25	1.2	26
LIFTOFF	1	0.4	44	0.08	24	1.1	22
SRB STEADY STATE	18	0.1	44	0.03	16	0.33	26
MAX Q	48	0.4	42	0.18	18	2.2	25
MAX G	88	0.4	42	0.07	25	2.0	25
POST SEPARATION	130	1.2	42	0.12	26	0.7	25

TABLE 3.3.0-18 STS-4 ET - CROSSBEAM D.C. ACCELEROMETER & LO2 LINE INLET PRESSURE GAUGE

	TIME	CROSSBEAM X-AXIS +/-G	END #2 FREQ HZ	LO2 LINE PRESSURE +/-G	INLET FREQ. HZ
SSME IGNITION	-2	0.1	30	7.0	1
LIFTOFF	1	0.3	34	5.8	9
SRB STEADY STATE	23	0.03	30	0.3	28
MAX Q	48	0.1	36	1.2	32
MAX G	88	0.1	38	1.3	30
POST SEPARATION	130	0.3	42	2.3	30

<u>LO2 TANK PRESSURES</u> - The original dome pressure gauge showed oscillatory pressures even higher (+/-20.0 psi and 4 Hz) than those experienced on STS-3. However, based on the new pressure, strain, and acceleration measurements on STS-4 and results of the Wyle testing of the pressure transducers, it appears that the dome oscillatory pressures at liftoff are from +/-5 psi to +/-7 psi. This dynamic pressure was determined from a new pressure gauge located in the LO2 line inlet about 15 inches below the tank bottom and from strain gauges on the dome. The high oscillatory pressures measured by the original dome gauge seem to reflect a phantom magnification because of its location on a structure experiencing high strains. Testing of the oscillatory pressure measurements in a test configuration at Wyle Laboratories using a flex bottom container verified that these measurements were erroneous. The six strain gauges flown on STS-2 were again flown on STS-4 and a typical gauge is shown in Figure 3.3.0-24 at liftoff. A plot of the pressure gauge location in the LO2 line inlet at liftoff is shown in Figure 3.3.0-25. In summary, it can be concluded that there is no LO2 dome problem at liftoff because of the Wyle test results, the new LO2 feedline pressure gauge, STS-2 and STS-4 strain data, new D.C. accelerometers located on the crossbeam, and predictions. The low frequency A.C. pressure and accelerometer measurements may be incorrect on the crossbeam and LO2 dome. New instrumentation will be proposed for STS-5 which will provide an analysis for the LO2 dome to crossbeam dynamic deflection analysis for VAFB at liftoff.

DATA SOURCE: STS4DB

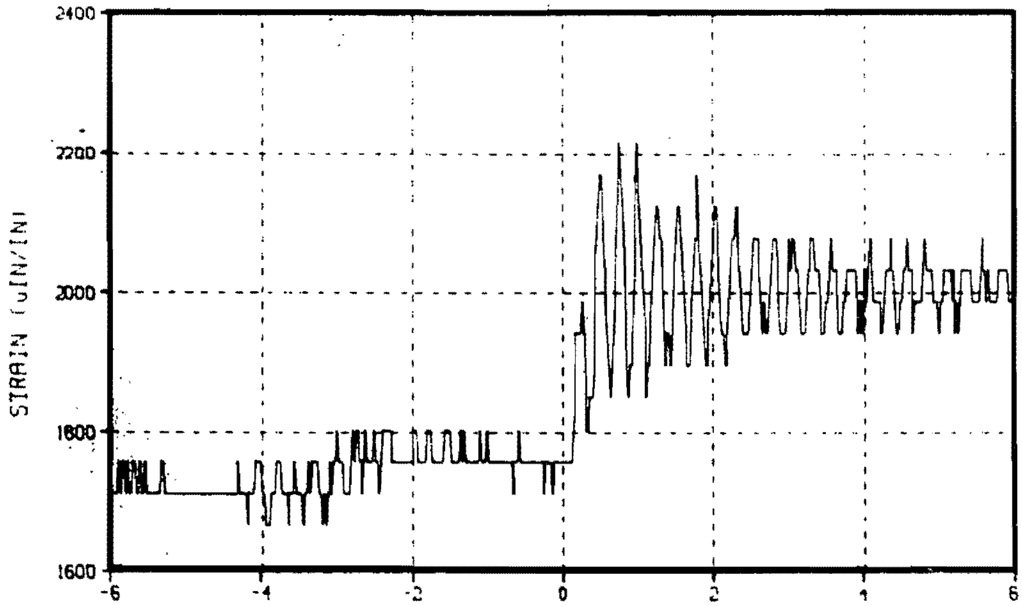


FIGURE 3.3.0-24 LO2 AFT STRAIN NO.4 (RAD)

DATA SOURCE: STS4DB

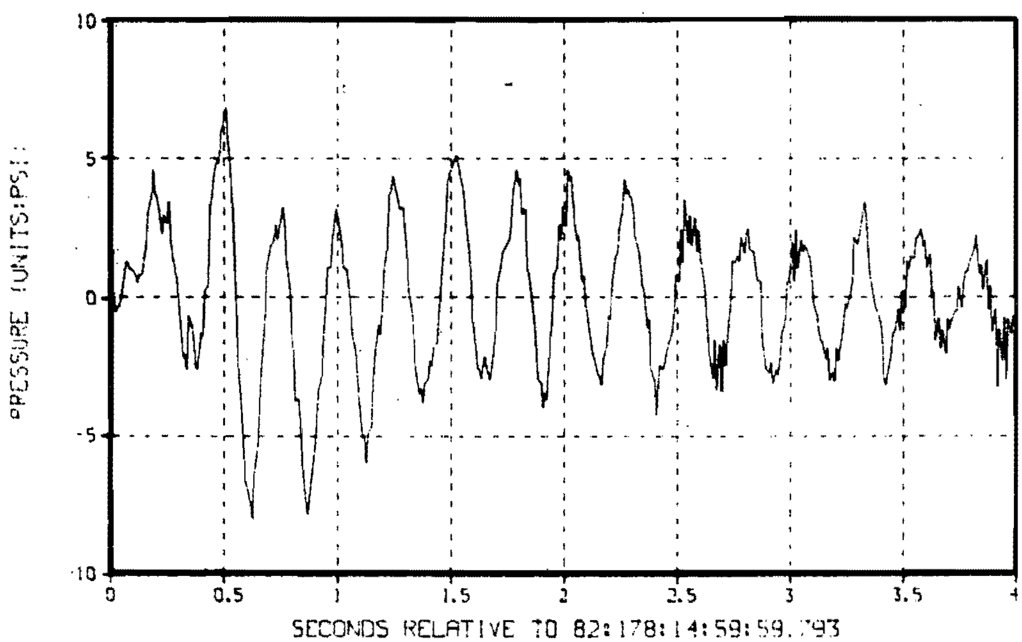


FIGURE 3.3.0-25 INTERTANK LO2 FEEDLINE PRESSURE (POGO)

The dynamic pressure was added to the static head and ullage pressure to obtain a total tank bottom pressure. At the Y ring no pressure gauge was available. Therefore, these oscillatory pressures were extrapolated (using the LO2 tank analytical modal data) to the

Y ring to determine dynamic pressure for this location. Static head pressure was calculated for the Y ring and combined with the oscillatory and ullage pressure to give a total pressure at this location. The tank bottom and Y ring pressures are listed in Table 3.3.0-19 for the LO2 dome pressure gauge, strain gauge, and the pressure gauge located in the LO2 line inlet. The strain and pressure transducer gauges are in close agreement.

TABLE 3.3.0-19 PRESSURES ON LO2 TANK BOTTOM & Y RING

	LO2 TANK BOTTOM (PSI)				Y RING (PSI)			
	STS-1	STS-2	STS-3	STS-4	STS-1	STS-2	STS-3	STS-4
PRESSURE GAUGE	63.9	64.7	68.4	69.0*	54.5	55.3	55.7	55.6*
STRAIN GAUGE	-	59.7	-	54.2**	-	50.1	-	45.8**
PRESSURE TRANSDUCER	-	-	-	55.0***	-	-	-	46.3***
DESIGN	70.6	70.6	70.6	70.6	57.5	57.5	57.5	57.5

*OSCILLATION PRESSURE - +/- 20 PSI
**OSCILLATION PRESSURE - +/- 5.2 PSI
***OSCILLATION PRESSURE - +/- 6.0 PSI

LH2 TANK AFT DOME PRESSURE - The LH2 tank dome pressure oscillations were considerably lower than the oscillations observed in the LO2 tank. These pressures (Table 3.3.0-9) were +/-7 psi in amplitude at a frequency of 5 Hz. The table below lists the pressures for all four flights after combining the ullage and static head pressures with the oscillatory.

LH2 TANK BOTTOM (PSI)

	STS-1	STS-2	STS-3	STS-4
PRESSURE GAUGE	42.6	41.3	36.9	36.9
DESIGN	44.3	44.3	44.3	44.3

The measured tank pressure level is 83% of the design pressure. No dynamic pressure predictions were made by the Rockwell International loads personnel for the LH2 tank because of the complexity of incorporating and using a hydroelastic model in their response analyses. In addition, no large dynamic pressures were expected because of the low density of the LH2 propellant. No explanation has been made for the drop in the LH2 pressure oscillations.

LH2 BARREL STRAIN GAUGES - The strains measured by the 19 gauges on the LH2 barrel at Sta. 1554 are used within a computer program (Barrel 4) written by MMC/MAF to evaluate the internal loads in the tank throughout the flight. These internal loads are from loads applied at the interfaces, from tank and propellant inertia and from airloads. They exclude internal loads from tank pressure.

The procedure used for calculations of these internal loads is as follows:

1. Determine the change in measured strains from a prelaunch time point with the tank full and essentially unpressurized (T-100 seconds) to the flight time of interest.

2. Subtract from these delta strains the pressure-induced strains.

3. The remaining delta strains (from flight-induced loads) are corrected for cross-sensitivity to give the corrected strains.

4. The total strain from external loads can now be found by adding back the strain due to 1G prelaunch loads (calculated analytically).

5. The total strains due to applied load (from 4. above) is converted to stresses using Hooke's Law.

6. The stresses in the X-direction are plotted and a sine curve fitted to them. The sine curve is the theoretical solution for bending an axial load on a thin-walled cylinder. (Figure 3.3.0-26).

7. The internal loads Px and My at Sta. 1554 are calculated using the mean stress to calculate the end load Px and the amplitude of the sine curve to calculate the end moment My.

Calculated loads from STS-1 thru STS-4 for different flight conditions are listed in Table 3.3.0-20 along with available predicted data from Rockwell International STS-1 Flight Readiness Review documents. Prelaunch axial load predictions are slightly lower due to changes in Orbiter and ET weights. Calculated loads at liftoff were compared with maximum predicted values.

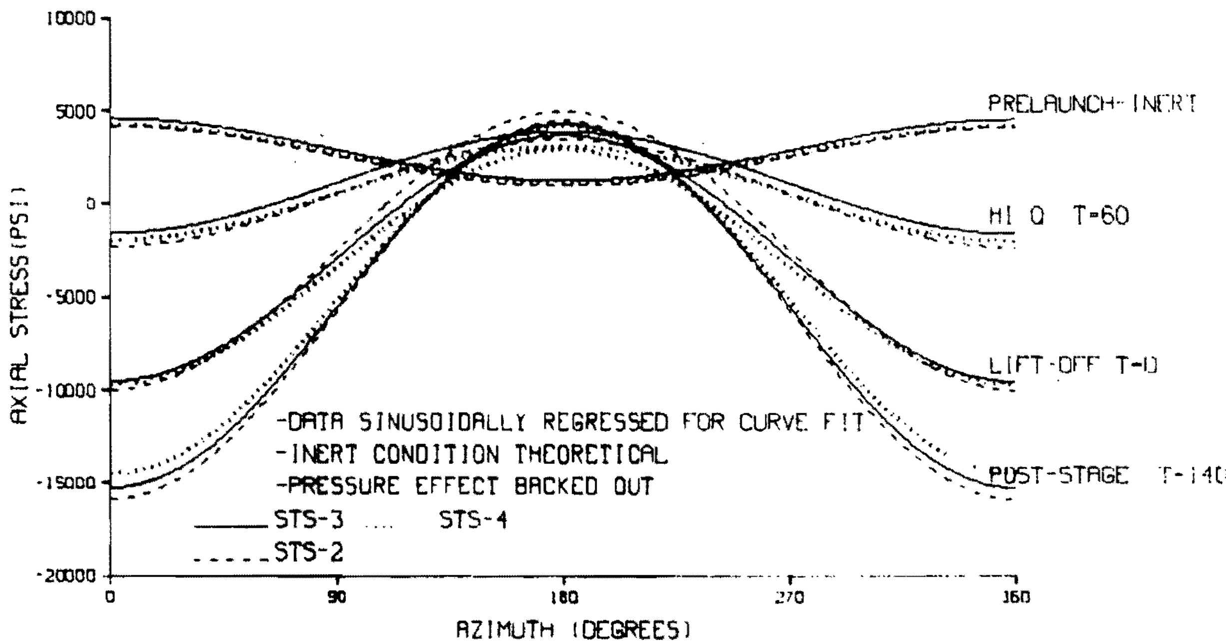


FIGURE 3.3.0-26 LH2 BARREL STA 1554 CIRCUMFERENIAL STRESS DISTRIBUTION

TABLE 3.3.0-20 LH2 BARREL AT STATION 1554

	MEAN STRESS (PSI)				DIFF. STRESS (PSI)				CAL. MAX STRESS (PSI)			
FLIGHT CONDITION	STS-1	STS-2	STS-3	STS-4	STS-1	STS-2	STS-3	STS-4	STS-1	STS-2	STS-3	STS-4
PL INERT	2618	2873	2608	2722	1583	1677	1592	1550	4201	4600	4200	4272
LO 0 SECS	-2761	-3220	-3646	-3311	-6778	-6625	-6196	-6321	-9539	-9462	-9842	-9632
HIQ 60 SECS	753	1104	603	639	-2550	-2542	-2554	-2530	-3003	-3646	-3157	-3177
PO 140 SECS	5474	-5449	-5663	-5587	-10110	-9815	-10197	-9669	-15584	-15264	-15860	-15256

FLIGHT CONDITION	END LOAD P_x (KIPS) STS-1	STS-2	STS-3	STS-4	PREDICTED	MOMENT M_y (KIP IN) STS-1	STS-2	STS-3	STS-4	PREDICTED
PL INSERT	483	530	480	501	430	25500	27000	25600	24900	24800
LO 0 SECS	-509	-593	-672	-610	-700	-108999	-106534	-99600	-101600	-110000
HIO 60 SECS	139	203	111	118	N.A	-40880	-44021	-41075	-40800	N.A.
PO 140 SECS	-1010	-1004	-1080	-1029	-1100	-163000	-155000	-165000	-156000	-167000

The post staging (PO) conditions (T approx. 140 sec.) were well within design as shown below:

MAXIMUM MEASURED

	DESIGN	STS-1	STS-2	STS-3	STS-4	STS-4 % DESIGN
STRESS	-17.4	-14.9	-15.6	-16.1	-15.3	88
END LOAD (KIPS)	-1210	-1010	-1100	-1080	-1029	85
MOMENT (KIPS)	-189000	-163000	-155000	-165000	-155000	82
P-EQ. END LOAD (KIPS)	-3500	-2980	-2970	-2960	-2908	83

<u>SRB CROSSBEAM AND LO2 FEEDLINE BRACKET STRAIN GAUGES</u> – The strain gauges on the SRB crossbeam flanges provide data to verify that the strains on the beam do not exceed design limits.

SRB CROSSBEAM STRAIN

ET SRB	MEASURED STRAIN RANGE STS-1	STS-2	STS-3	STS-4	LIMIT ALLOWABLE STRAIN RANGE	MAX % LIMIT STS-4
FWD FLANGE (IN-IN)	400/-1180	190/-1410	300/-1380	380/-1350	2480/-200	68
AFT FLANGE (IN-IN)	1475/-220	1550/-180	1550/-135	1550/-145	2480/-2000	63

The measured strain on both the forward and aft flanges were well within the limit allowable range, with the maximum measured strain reaching 68% of the limit allowable. This comparison is based on strength rather than stiffness (the criteria used for the crossbeam design).

The measured strain range on the LO2 feedline bracket strain gauges were well within the limit allowable strain range, with the maximum measured strain reaching 14% of limit allowable.

LO2 FEEDLINE BRACKET STRAINS

	MEASURED STRAIN RANGE STS-1	STS-2	STS-3	STS-4	LIMIT ALLOW. STRAIN RANGE	MAX. % LIMIT ALLOW STS-4
ALL POSITIONS (IN-IN)	352/-342	386/-324	367/-302	385/-366	3320/-2490	14%

Although the above is based on data that is not compensated for temperature, the strain range indicated will largely be unaffected as temperature changes are small.

FORWARD ET/SRB ATTACH LOADS - The following table snows the forward attach loads FTB5 and FTB6 for three flight times.

TIME	MEASURED LOAD (KIPS)			
(SEC)	STS-1	STS-2	STS-3	STS-4
0	-366	-362	-384	-356
60	-1214	-1219	-1168	-1160
80	-1474	-1479	-1503	-1520

PREDICTED 3 SIGMA LOAD (LOWEST) 1358
(HIGHEST) 1547

DESIGN LOAD 1672

The loads fall within the predicted 3 sigma loads obtained from Rockwell International. The measured loads are derived from the ET intertank strain data and are within the design limit.

SUMMARY - The ET structural loads and stresses have been evaluated from the STS-4 measured strains, pressures, and accelerometer data from pre-launch through the ascent flight regime. All loads, stresses, pressures and acceleration responses were within the design limit throughout flight and were compared with STS-1, STS-2, and STS-3 results.

All ET/ORB strut loads for STS-4 were similar to STS-3 and STS-2 and generally lower than for STS-1 during build-up and liftoff. P1 and P2 were lower for max q because of the higher angle of attack which reduced the loads on the forward struts. P3 was higher (max q) but was more in line with P4. The vertical strut loads were higher and the thrust strut loads were lower for maximum SRB acceleration compared with STS-3. The same general trend held for pre-SRB staging. Post SRB staging, orbiter max burn, and orbiter end burn loads were similar to the first three flights.

Based on results of the new pressure, strain, and acceleration measurements on STS-4 and results of the Wyle testing of the pressure transducer, it appears that the dome oscillatory pressure at liftoff are from +/-5 psi to +/-7 psi at 4 Hz. These results contradict the large oscillatory pressures measured by the pressure gauge located on the LO2 dome. These high pressures seem to reflect a phantom magnification because of its location on a structure experiencing high strains, and it appears that there is no LO2 dome pressure anomaly for the KSC liftoff transients. However, new instrumentation will be proposed for STS-5 because small exceedances of design pressures can be expected for a VAFB liftoff. The LH2 pressure gauge measured +/-7 psi at 5 Hz compared with +/-12.7 psi at 7 Hz for STS-1, +/-11.4 psi at 6 Hz for STS-2, and +/-7 psi at 6.5 Hz for STS-3. There is no explanation to explain the decrease from the first two flights. No oscillatory pressures have been calculated by RI for the LH2 tank because their all-up systems model does not contain a hydroelastic LH2 tank. These dynamic pressures, when added to the static head and ullage pressure, result in the following total pressures for the pressure gauge located in the LO2 line inlet:

(a) LO2 measured pressure at dome = 65.0 psi
design = 70.6 psi

(b) LO2 tank Y ring (extrapolated) from dome = 46.3 psi
design = 57.5 psi

(c) LH2 aft dome measured pressure = 36.9 psi
design = 44.3 psi

The percent of measured levels to the design limit pressures is 78% for the LO2 tank bottom, 81% for the LO2 tank Y ring, and 83% for the LH2 tank dome. The new D.C. accelerometers agree with expected values on the SRB crossbeam (+/-0.1 g) and the existing A.C. accelerometers continue to have higher than predicted values and to disagree with the D.C. accelerometers. Two A.C. accelerometers on the LO2 aft dome still have a 4 Hz frequency, but they do not agree with each other or the strain gauges.

Table 3.3.0-21 shows the load comparison in percent of design for the struts, crossbeam, LO2 dome, Y ring, and LH2 dome.

TABLE 3.3.0-21 LOADS COMPARISON IN % OF DESIGN

STRUCTURE	STS-1	STS-2	STS-3	STS-4
	%(EVENT)	%(EVENT)	%(EVENT)	%(EVENT)
P1	52 (LIFTOFF)	44 (POST SRB STG.)	45 (POST SRB STG.)	43 (POST SRB STG.)
P2	50 (LIFTOFF)	42 (POST SRB STG.)	41 (POST SRB STG.)	44 (POST SRB STG.)
P3	53 (POST SRB STG.)	55 (POST SRB STG.)	50 (POST SRB STG.)	54 (MAX Q)
P4	53 (POST SRB STG.)	50 (POST SRB STG.)	56 (MAX Q)	56 (MAX Q)
P5	91 (POST SRB STG.)	87 (POST SRB STG.)	88 (PRE SRB STG.)	88 (PRE SRB STG.)
P6	88 (POST SRB STG.)	85 (POST SRB STG.)	88 (PRE SRB STG.)	85 (PRE SRB STG.)
P7	12 (MAX Q)	6 (PRE SRB STG.)	18 (PRE SRB STG.)	10 (PRE SRB STG.)
CROSSBEAM	88 (MAX SRB ACCEL.)	88 (MAX SRB ACCEL.)	90 (MAX SRB ACCEL.)	91 (MAX SRB ACCEL.)
LO2 DOME	91 (LIFTOFF)	92 (LIFTOFF)	97 (LIFTOFF)	78 (LIFTOFF)
Y RING	95 (LIFTOFF)	96 (LIFTOFF)	97 (LIFTOFF)	81 (LIFTOFF)
LH2 DOME	96 (LIFTOFF)	93 (LIFTOFF)	83 (LIFTOFF)	83 (LIFTOFF)

3.4.0 PRESSURE AND VIBROACOUSTICS

3.4.1 NOSE CAP AND INTERTANK COMPARTMENT VENTING - The compartment venting of the ET nose cap and intertank and the differential pressures at three intertank locations were calculated using the Quick Look Best Estimated Trajectory (BET). The comparison of calculated and flight nose cap compartment pressure is shown in Figure 3.4.1-1. It should be noted that the flight data have been biased by +1.6 psi as recommended in MMC Data Squawk 156. The prediction is slightly lower than flight data.

The intertank compartment differential pressure referenced to ambient is shown in Figure 3.4.1-2. The flight data is computed as the difference between the intertank pressure transducer (T07P9562A) and the ambient pressure from the BET. As seen in the figure the predicted values are slightly higher than flight data and within the instrument tolerance range of +/- 0.6 psi.

Figures 3.4.1-3 through 3.4.1-5 show the differential pressures across the intertank wall at three locations. These are: two feet in front of the ET Orbiter attach bipod (3.4.1-3), seven feet in front of the RH SRB attach fitting (3.4.1-4), and seven feet behind the RH SRB attach fitting (3.4.1-5). All of the differential wall pressure flight values are within the instrument tolerance range around the predictions.

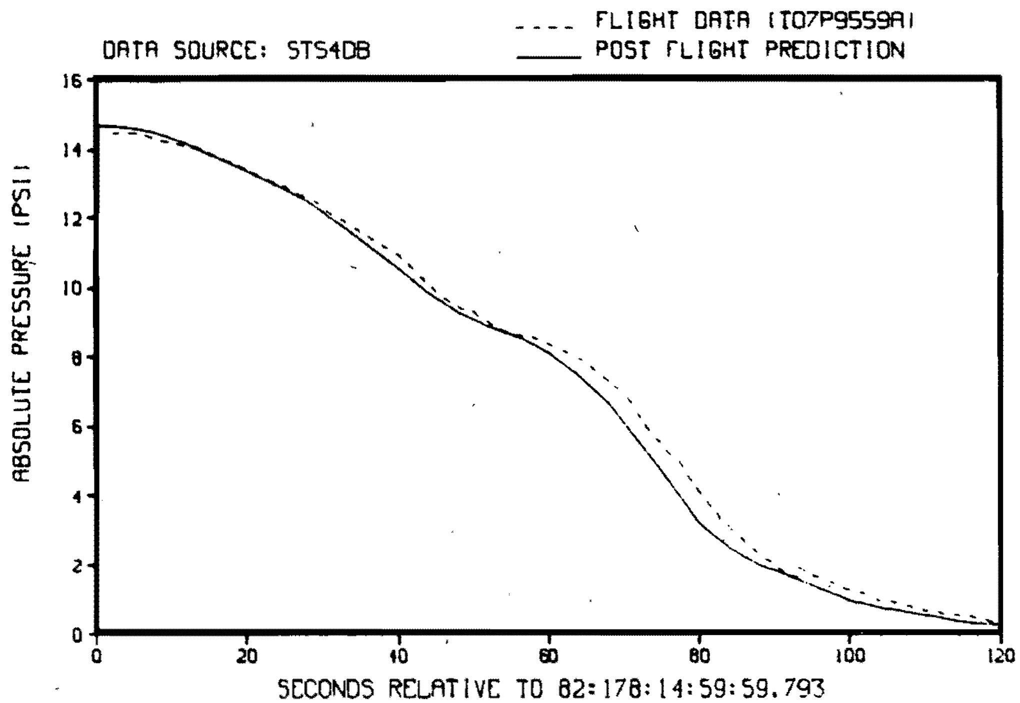


FIGURE 3.4.1-1- ET NOSE CAP INTERNAL PRESSURE

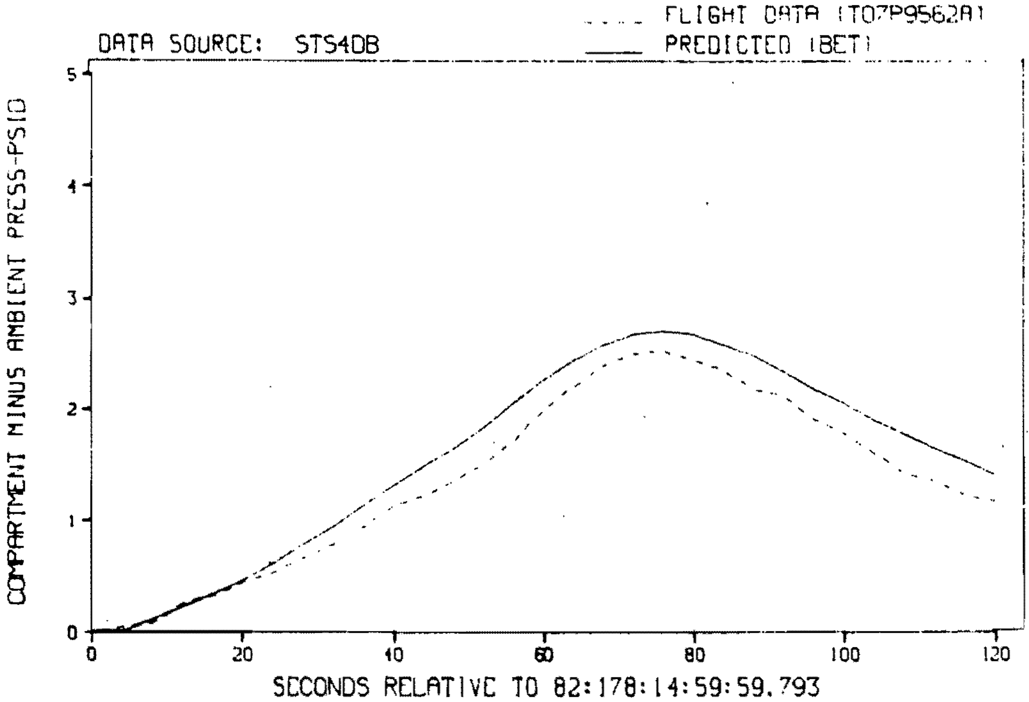


FIGURE 3.4.1-2 ET INTERTANK INTERNAL PRESSURE

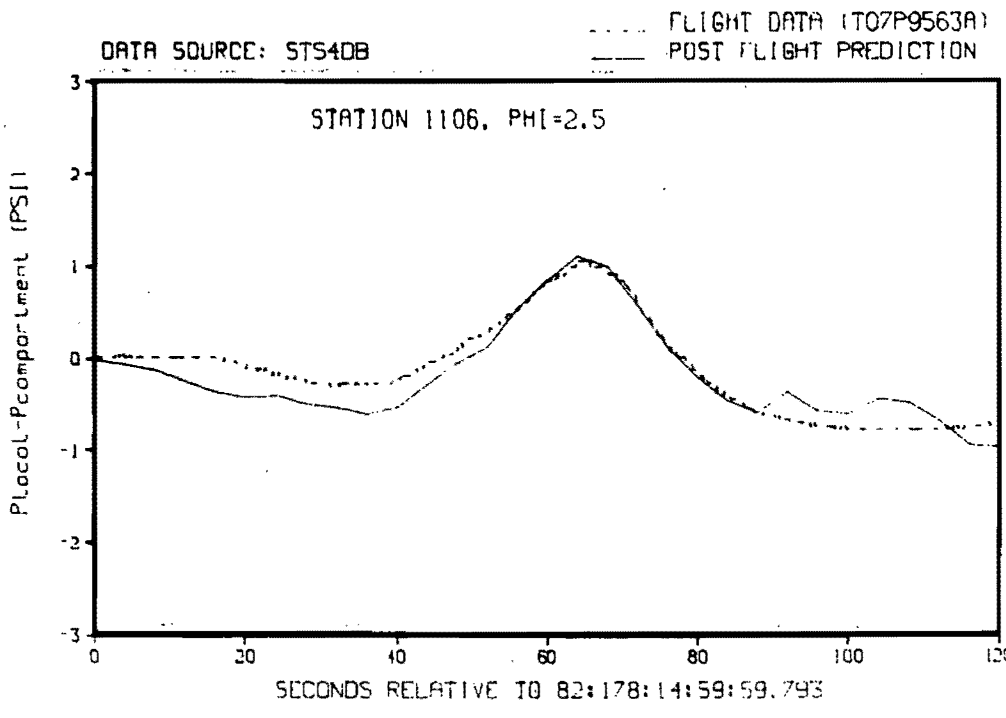


FIGURE 3.4.1-3 ET INTERTANK DIFFERENTIAL PRESSURE

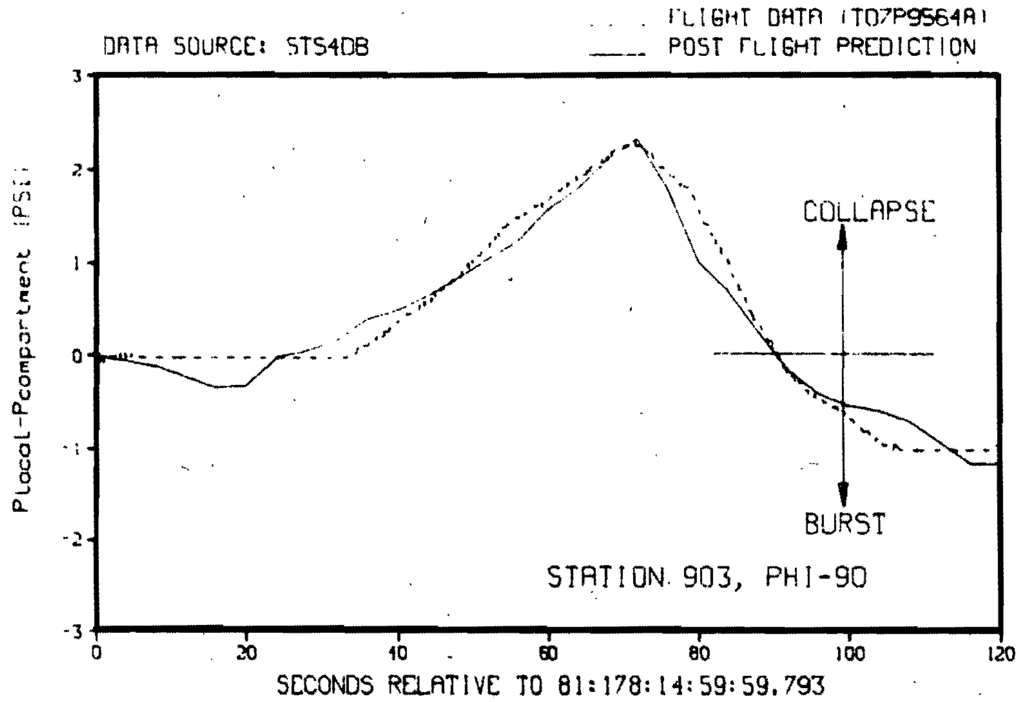


FIGURE 3.4.1-4 ET INTERTANK DIFFERENTIAL PRESSURE

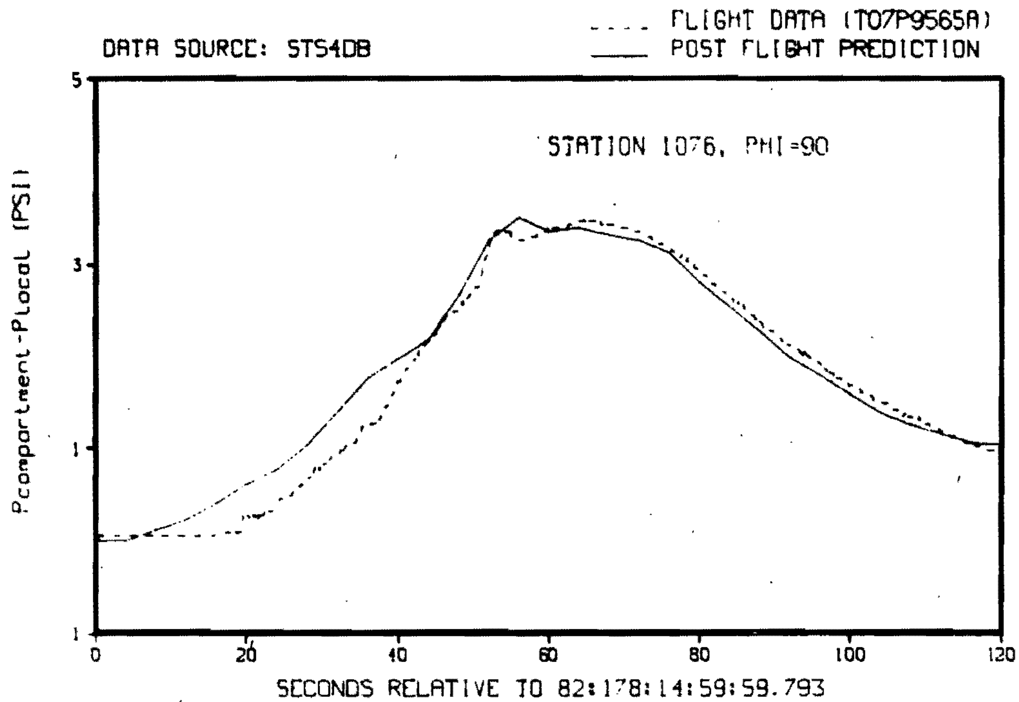


FIGURE 3.4.1-5 ET INTERTANK DIFFERENTIAL PRESSURE

3.4.2 ET VIBROACOUSTICS - The vibroacoustic measuring program for the ET on STS-4 consisted of 31 vibration and eight acoustic measurements. Twenty-nine vibration and seven acoustic measurements provided good data. One vibration channel (T08D9262A) was dead and one (T08D9261A) appears to have a bad connector or cable. One acoustic measurement (T08Y9956A) has consistantly provided unreasonably low data as shown in Figure 3.4.2-1. This problem could be caused by ice or water in the holes of the metal heat shield of the transducer attenuating the sound level. An ECR has been submitted to replace the transducer with a transducer having no heat shield. Generally, ET vibration and acoustic levels compared very well to STS-1, STS-2, and STS-3 data and were within predicted criteria. Typical acoustic plots are presented in Figure 3.4.2-2 and typical vibration plots are given in Figure 3.4.2-3.

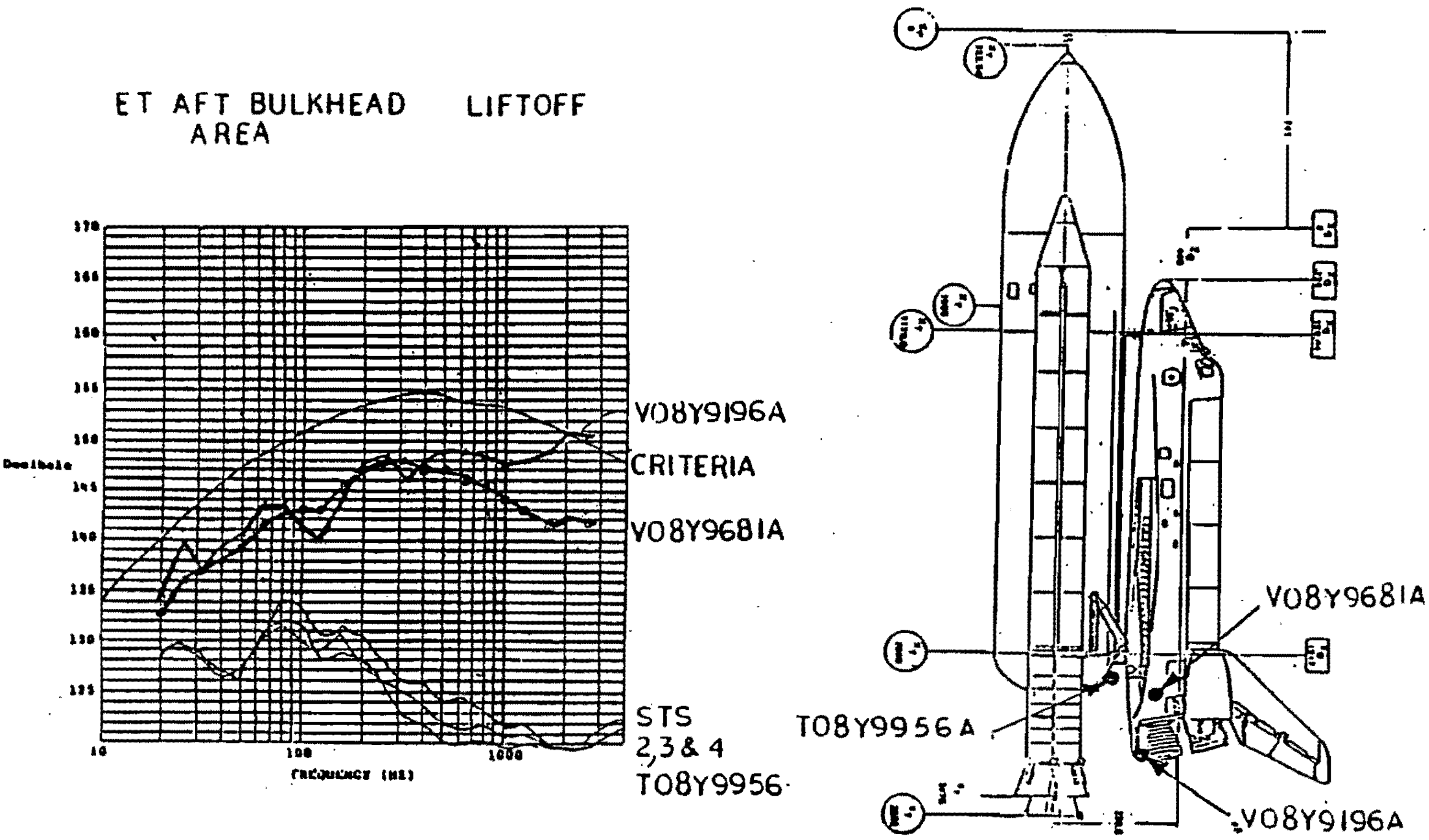


FIGURE 3.4.2-1 LOW LEVELS FOR ACOUSTIC SENSOR T08Y9956

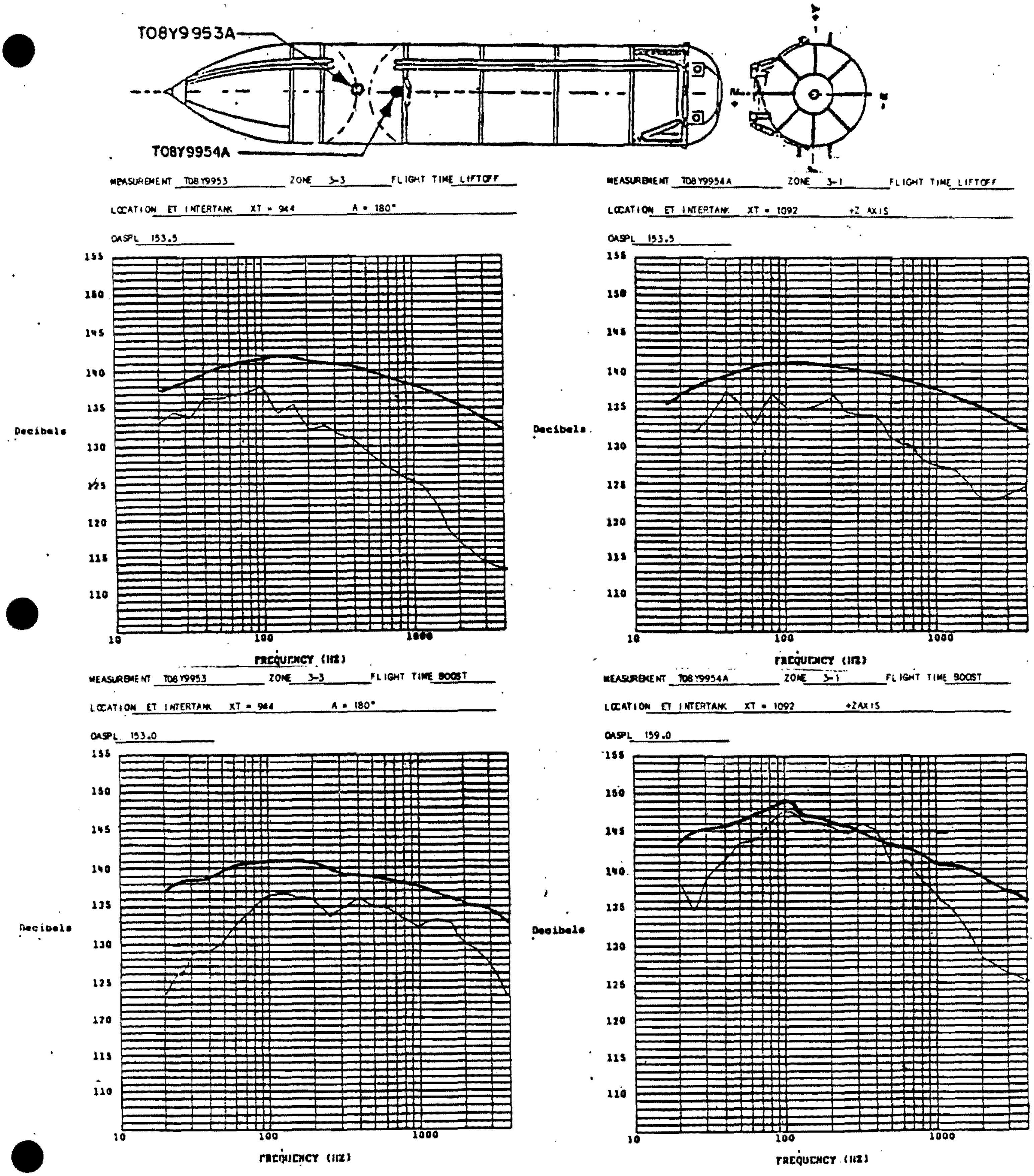


FIGURE 3.4.2-2 TYPICAL ACOUSTIC DATA

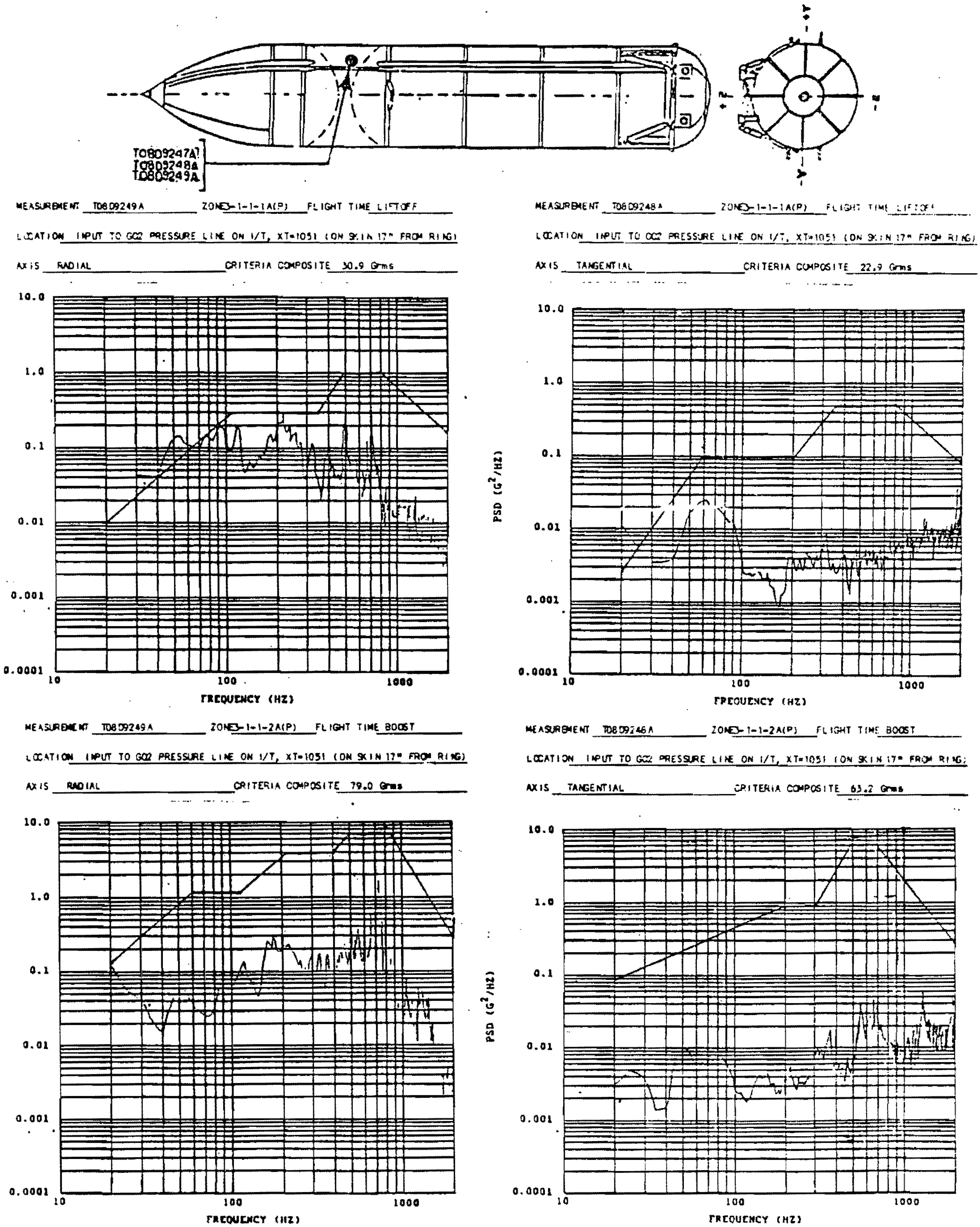


FIGURE 3.4.2-3 TYPICAL VIBRATION DATA

3.5.0 THERMAL ASSESSMENT - ET thermal conditions are monitored using numerous ET mounted structural and compartment measurements designated as either Operational Instrumentation (OI), mandatory for flight, or as Developmental Flight Instrumentation (DFI), used for design assessment after flight. Another source of thermal monitoring is ground support instrumentation such as purge heater temperatures. A review of thermal data shows no LCC or OMRSD violations. All facility supplied ET thermal conditioning was sufficient to maintain acceptable prelaunch temperatures and there were no anomalies with TPS acreage performance. During flight, recorded skin and structural temperatures were in the mid range of predictions and component temperatures remained at or near liftoff values.

3.5.1 PRELAUNCH THERMAL ENVIRONMENT - Active conditioning and heating systems are utilized for certain areas of the ET to maintain specific requirements. These areas consist of the nose cone and intertank (I/T) compartments, LH2 and LO2 pressurization lines, ET/ORB forward bipod fittings and aft feedline attachment hardware. The ET Thermal Protection System (TPS) is used for passive control.

3.5.1.1 NOSE CONE COMPARTMENT PURGE - For the nose cone compartment, a dry gaseous nitrogen (GN2) purge is used to preclude hazardous gas concentrations and moisture buildup. This purge is heated and temperature controlled to prevent formation of ice/frost around vent areas and to provide thermal conditioning for electronic components within the compartment.

The nose cone purge heater is actively controlled by the facility using temperature feedback either from redundant OI nose gas sensors or from a sensor at the heater outlet. LO2 tanking conditions determine the set point value and sensor with which the heater is controlled. During initial LO2 loading operations, the heater was controlled by an OI nose gas sensor using an 85 deg-F set point (Figure 3.5.1-1). As LO2 load neared 100%, heater control was switched to a heater outlet probe with a set point value of 300 deg-F which remained in force until purge termination just prior to liftoff. ET-4 nose cone temperatures are similar to those of ET-2 and ET-3. ET-1 nose cone temperature data are cooler because foam had not yet been added to the GO2 vent duct. A summary of measurements associated with the nose compartment purge system, required limits and corresponding predicted and measured data ranges, is presented in Table 3.5.1-1.

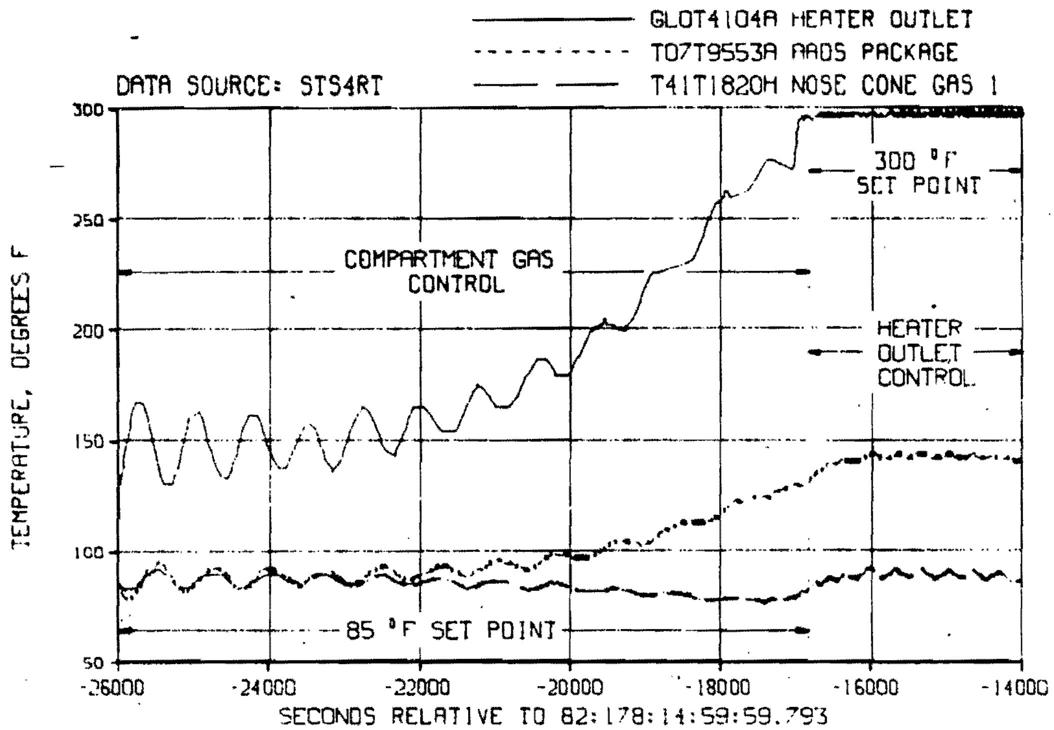


FIGURE 3.5.1-1 NOSE CONE PURGE TEMPERATURES DURING TANKING

TABLE 3.5.1-1 NOSE COMPARTMENT PURGE

PARAMETER	LIMITS	PREDICTED	ACTUAL
HEATER OUTLET (DEG-F)	325 MAX (OMRSD)	300 MAX	300 MAX
COMPARTMENT GAS (DEG-F)	55 - 130 (LCC)*	55 - 110	77 - 104
AADS PACKAGE (DEG-F)	200 MAX (QUAL)	AMB - 150	79 - 146
NOSE CONE SKIN (DEG-F)	200 MAX (DSGN)	AMB - 180	72 - 160
LO2 C/T AT LSC (DEG-F)	140 MAX (DSGN)	AMB - 100	69 - 88
PURGE PRESSURE (PSIG)	2200 MAX (ICD)	1900 - 2005	1910 - 1980

*LOWER LIMIT EXCEEDANCE ALLOWANCE - 15 MINUTES

3.5.1.2 INTERTANK COMPARTMENT PURGE - For the I/T compartment, a dry GN2 purge, used to preclude hazardous gas concentrations and moisture buildup, is heated and temperature controlled to prevent formation of ice/frost around vent areas and to provide thermal conditioning for electronic components within the compartment. Temperature control is also required in order not to exceed maximum I/T skin liftoff temperature.

The I/T purge heater is actively controlled using temperature feedback from redundant OI I/T gas sensors. Cryo tanking requires an initial set point of 80 deg F to offset initial thermal shock of a cold LO2 dome. After the LO2 aft dome is full and as LH2 load level approaches 100%, the set point is stepped down to 55 deg F by increments of 5 deg F (Figure 3.5.1-2). A summary of measurements associated with the I/T compartment purge system, required limits and corresponding predicted and measured data ranges, is presented in Table 3.5.1-2.

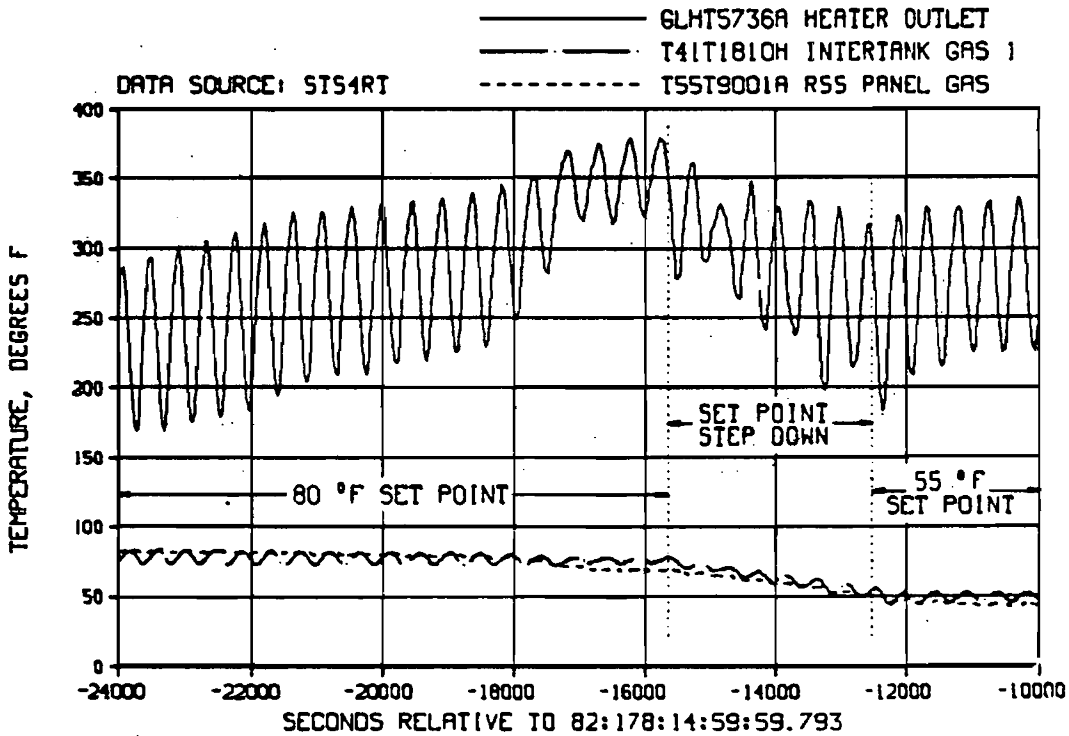


FIGURE 3.5.1-2 INTERTANK PURGE TEMPERATURES DURING TANKING

TABLE 3.5.1-2 INTERTANK COMPARTMENT PURGE

PARAMETER	LIMITS	PREDICTED	ACTUAL
HEATER OUTLET (DEG-F)			
LOADING	500 MAX	391 MAX	380 MAX
PRELAUNCH	500 MAX	260 - 370	220 - 350
COMPARTMENT GAS (DEG-F)			
LOADING	33 - 118 (OMRSD)	33 - 90	72 - 89
PRELAUNCH	33 - 58.5 (LCC)*	33 - 58	42 - 54
I/T SKIN (DEG-F)			
LOADING	N. A.	33 - 90	68 - 80
PRELAUNCH	60 MAX (DSGN)	55 MAX	51 MAX
RSS BATTERY (DEG-F)	30 - 120 (DSGN)	33 - 90	42 - 83
PURGE PRESSURE (PSIG)	3090 MAX (ICD)	2750 - 2950	2920 - 2940

*LOWER LIMIT EXCEEDANCE ALLOWANCE - 15 MINUTES
UPPER LIMIT EXCEEDANCE ALLOWANCE - 5 MINUTES

3.5.1.3 PRESSURIZATION LINE ANTI-ICING PURGES - During prelaunch operations, GO2 and GH2 pressurization lines are purged with helium which is heated in order to prevent ice/frost formations at line attachments to the ET. Limits, predictions and measured temperatures for the anti-icing purge at the heater outlet and at LO2 and LH2 diffuser inlets are presented in Table 3.5.1-3. Measured temperatures imply no ice/frost formations on pressurization lines and no ice/frost formations were observed.

TABLE 3.5.1-3 PRESS LINE ANTI-ICING PURGE

PARAMETER	LIMITS	PREDICTED	ACTUAL
HEATER OUTLET (DEG-F)	240 - 260 (OMRSD)	240 - 260	240 - 249
LO2 TANK INLET (DEG-F)	32 MIN (DSGN)	40 - 100	72 - 85
LH2 TANK INLET (DEG-F)	32 MIN (DSGN)	40 - 100	59 - 85

3.5.1.4 BIPOD AND AFT FEEDLINE BRACKET HEATERS - For ET/ORB forward bipod spindles and aft feedline attachment brackets, electrical heaters are used to prevent ice/frost formations. Allowable temperature and current limits for these heaters are summarized in Table 3.5.1-4 along with corresponding predictions and measured data.

Each bipod spindle contains a 160 watt calrod heater which is activated prior to LH2 loading. These heaters are separately controlled using on/off switching in response to a temperature sensor on each spindle with control set points of 60 deg F. Temperatures on either spindle were maintained between 56 deg F and 78 deg F.

Aft LO2 and LH2 feedline support brackets require heaters to prevent ice/frost formations where the brackets attach to the crossbeam. These heaters have no means of active control or temperature monitoring. In accordance with requirements established through MPTA testing, LO2 heaters were activated 20 minutes after LO2 ECO sensors indicated wet and LH2 heaters were activated 75 minutes after LH2 low level sensors indicated wet.

TABLE 3.5.1-4 ANTI-ICING HEATERS

PARAMETER	LIMITS	PREDICTED	ACTUAL
ORB/ET BIPOD CONTROL TEMP (DEG F)	41 - 191 (LCC)	50 - 70	56 - 78
AFT ATTACHMENTS			
LH2 INBD BRKT (AMP)	.095 - .155 (OMRSD)	.105 - .145	.118 - .125
LH2 OUTBD BRKT (AMP)	.280 - .460 (OMRSD)	.320 - .420	.374 - .388
LO2 FDLN BRKTS (AMP)	1.35 - 1.85 (OMRSD)	1.40 - 1.80	1.60 - 1.70

3.5.1.5 TPS PERFORMANCE - The ET Thermal Protection System (TPS) is designed to maintain cryogenic propellant quality, protect the structure from ascent and plume heating, and minimize ice/frost and liquid air formations. An optimum thickness of insulation precludes icing for most ambient conditions at KSC while maintaining a reasonable subsystem weight. Table 3.5.1-5 presents ambient conditions encountered during prelaunch and predicted TPS surface temperatures for the range of wind speeds experienced. As shown, predicted surface temperatures range from 58 deg F to 73 deg F. To assess prevailing ambient conditions during launch operations against TPS design capability, an LCC was developed in the form of ice rate nomographs. Figure 3.5.1-3 presents the nomograph applicable for the LH2 tank in areas of calm wind together with a track of ambient conditions experienced during loading. As seen in this figure, recorded ambient conditions are well to the right of any icing conditions and there was no ice/frost observed on ET-4 acreage.

TABLE 3.5.1-5 TPS PERFORMANCE

AMBIENT CONDITIONS		PREDICTIONS (ACREAGE)		
TEMPERATURE	76 - 85 DEG F	WIND (KNOTS)	.5	2.5
HUMIDITY	70 - 93 %			
DEW POINT	67 - 72 DEG F	OGIVE	68	73
WIND SPEED	1.5 - 6 KNOTS	LO2 BARREL	61	64
WIND DIRECTION	135 - 180 DEG	LH2 BARREL	58	62
LOCAL WIND (ET SURFACE)	.5 - 2.5 KNOTS	(80 DEG-F AND 70 % RH)		

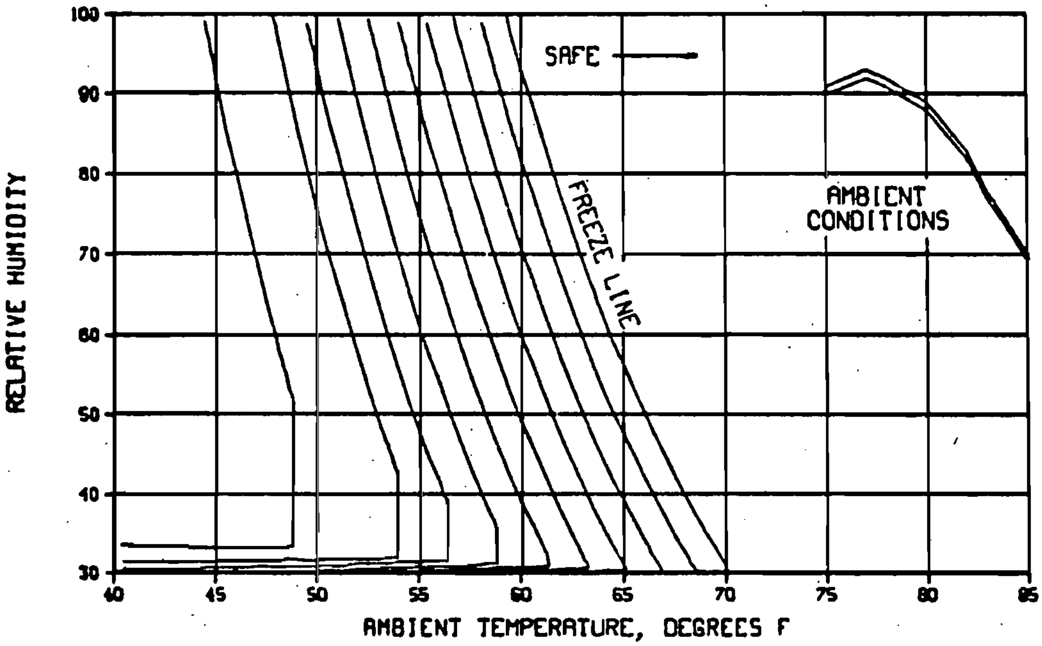


FIGURE 3.5.1-3 ICE/FROST NOMOGRAPH FOR LH2 TANK ACREAGE WITH CALM WIND

3.5.2 STRUCTURAL TEMPERATURES/TPS EVALUATION - All ET skin and structural temperature measurements are mounted under TPS, either on attachments (Figure 3.5.2-1), or on tank skin (Figure 3.5.2-2). Data from these measurements and associated correlations confirm the adequacy of TPS sizing and performance and substantiate the capability to accurately predict inflight transient temperature.

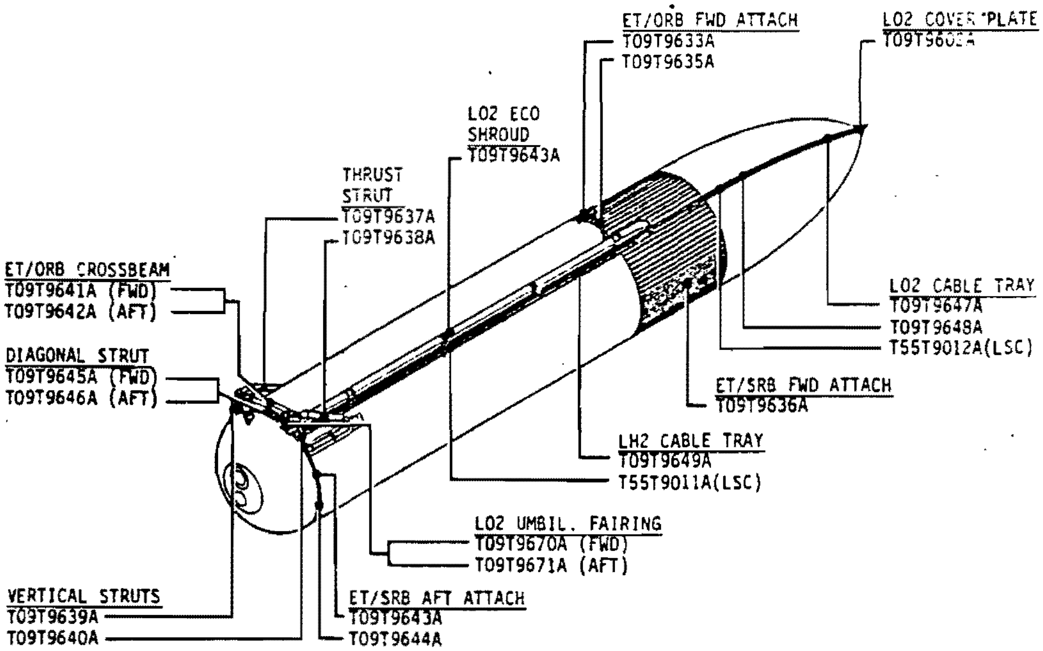


FIGURE 3.5.2-1 ET ATTACHMENT TEMPERATURE MEASUREMENTS

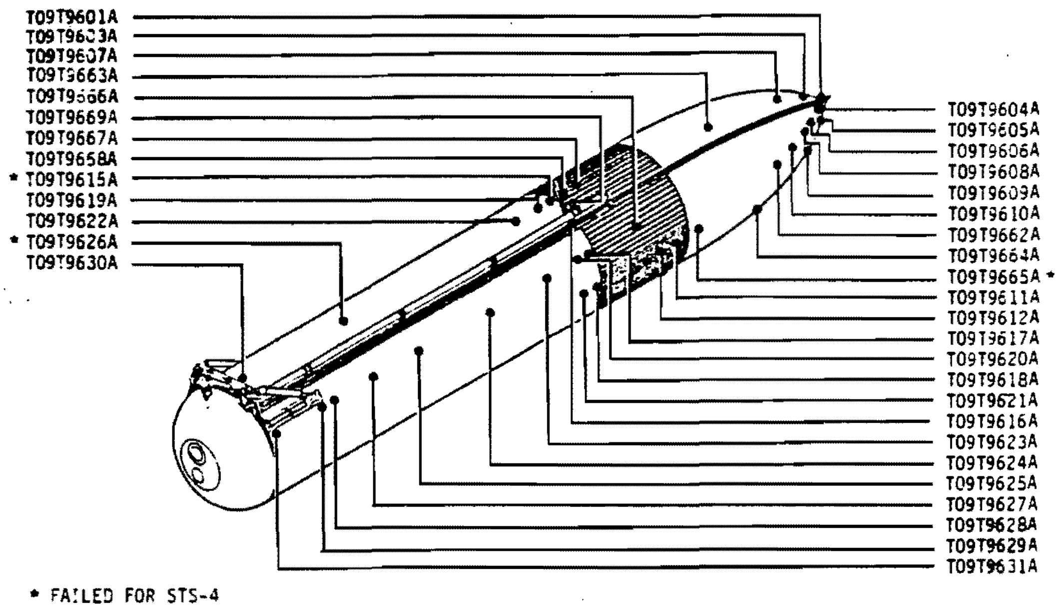


FIGURE 3.5.2-2 ET SKIN TEMPERATURE MEASUREMENTS

Aeroheating environments for STS-4 are reported to be slightly higher than previous flights. This is observed on separation film where SOFI charring is more evident on ET-4 than on ET-3. Charred areas include the LO2 feedline, thrust strut, longerons, and I/T fairings and area around these fairings. Also on separation film, popcorning on the aft dome is significantly more evident than on previous flights. SOFI popcorning is not considered to be an impact to thermal protection but is indicative of material variance. From separation slides, recession plugs are visible on the LH2 tank on the aft barrel section, +Z axis, and along the LO2 feedline. Based on these data there was less than 1/4 inch SOFI recession.

Some ice/frost remained on various waiver areas. These included anti-geyser line bellows and around the edge of instrument island 33. White areas visible on LH2 tank in SLA areas are the same as observed on ET-3. These are judged to be solid air formations.

Two sections of the upper LH2 cable tray PAL ramp were lost. The largest section, STA 1160, is approximately 30 inches long and the second section, STA 1400, is approximately 20 inches long. SOFI divots are apparent at the LH2-I/T splice. These are located approximately 50 deg from the +Z axis and are from 3 to 9 inches in diameter. This TPS loss is minor and does not degrade flight performance.

3.5.2.1 LO2 TANK - LO2 skin and structural temperatures responded as expected. Measured and predicted external heating environments are slightly greater than on previous flights while GO2 ullage temperatures are slightly lower. Since internal heating from the GO2 ullage has dominant influence on temperature change, skin temperature traces from ET-4 are slightly lower than previous flights. Figure 3.5.2-3 presents measured data traces, grouped at forward locations, along with analytical predictions using varying internal heat transfer coefficients. Analytical correlations assume forced convection for the ogive area and natural convection after liquid uncover for the barrel section.

Recorded temperatures from the measurement at STA 441, Theta = 180 (T09T9809A) are approximately 20 deg F warmer at MECO than temperatures from measurements at the same station but different thetas. Per configuration drawings, SLA exists under foam back to STA 440. Since the measurement location is at STA 441 +/- 6 inches, some of STA 441 measurements could be under SLA and others not. Per analyses, a measurement at STA 441 not covered with SLA shows approximately a 20 deg F greater increase in temperature than one that is covered with SLA.

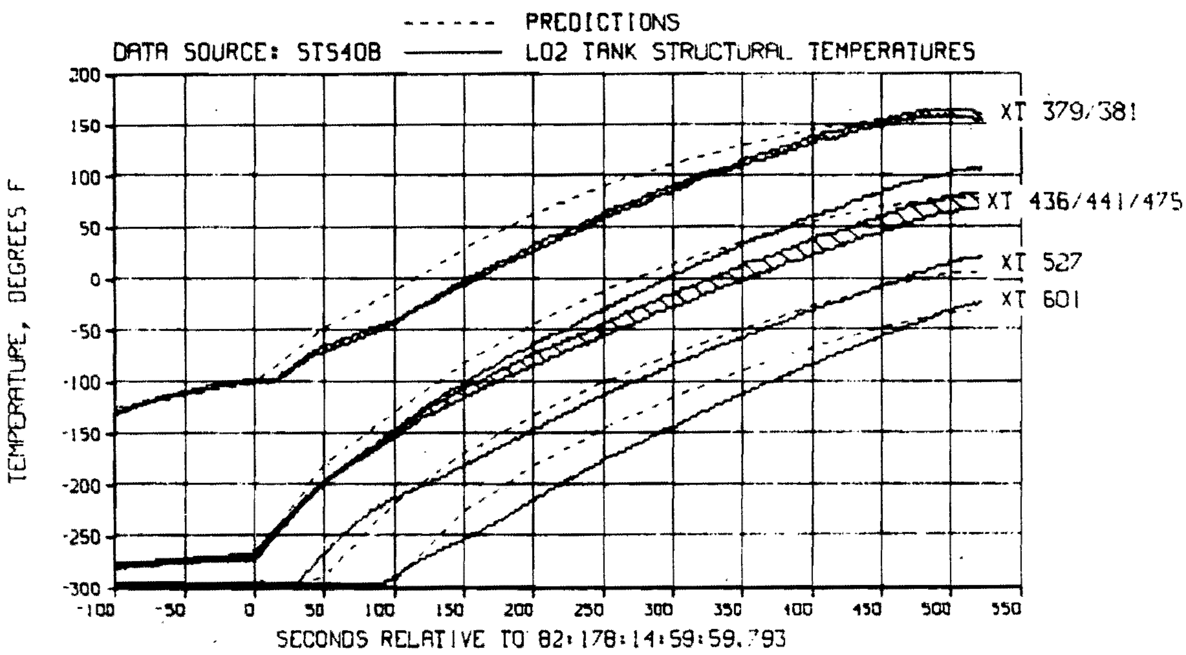


FIGURE 3.5.2-3 LO_2 SKIN TEMPERATURE CORRELATIONS

3.5.2.2 INTERTANK - Intertank skin temperature data shows minimal response due to aeroheating. Data from locations between forward and aft frames remain within 10 deg-F of prelaunch steady state temperatures. Sensors located in the crotch between the aft I/T frame and the LH2 tank splice show a decrease in temperature due to conduction from the splice joint and loss of warming from I/T purge gas. These data are all similar to those recorded on previous flights and are consistent with predictions.

3.5.2.3 LH2 TANK - LH2 skin and structural temperature traces responded as expected due almost entirely to liquid draindown and the subsequent exposure of the inner skinline to a warmer LH2 ullage. Correlation analyses using the same models developed for ET-1 provide similar good agreement. Ullage velocities are very low, therefore correlations are made using heat transfer coefficients provided by natural convection.

Boundary conditions driving ET-4 LH2 tank skin temperatures are very close to those experienced on previous flights; hence, temperature transients for corresponding temperature measurements are in close agreement. Figure 3.5.2-4 presents ET-4 data at measurement locations indicated along with representative analytical correlation traces for stations 1137, 1618, 1874 and 2046. A 25 deg F deviation is well within expected range of divergence between analytical and data.

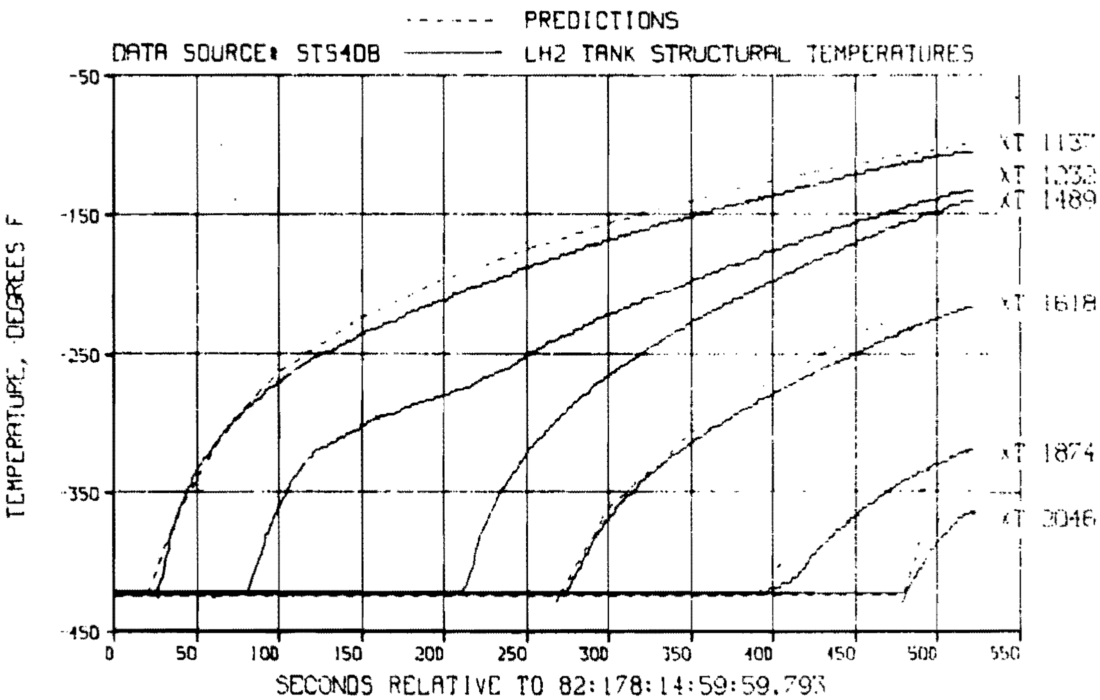


FIGURE 3.5.2-4 LH2 TANK SKIN TEMPERATURE CORRELATIONS

3.5.2.4 ATTACHMENTS - Temperature sensors on attachments responded as expected with no big surprises. Maximum temperatures and the maximum temperature change recorded for each attachment on ET-1 through ET-4 are presented in Table 3.5.2-1. This comparison shows that aeroheating on each flight had a similar impact on attachment temperatures. The slightly higher aeroheating environment reported for STS-4 is evident in temperature data for the bipod strut, diagonal strut and ET/SRB forward attach fitting. On other attachments, slight differences in heating are not reflected in flight temperature deltas because of excessive insulation. Higher maximum temperatures for these attachments result from a warmer ambient temperature.

TABLE 3.5.2-1 ATTACHMENT STRUCTURE TEMPERATURES

ATTACHMENT	FLIGHT DELTA (DEG-F)				FLIGHT MAXIMUM (DEG-F)			
	ET-1	ET-2	ET-3	ET-4	ET-1	ET-2	ET-3	ET-4
BIPOD STRUTS	11	14	12	22	80	80	86	105
ET/SRB FWD ATTACH	11	24	23	28	68	82	81	90
THRUST STRUT	15	16	15	13	72	78	78	88
VERTICAL STRUT	1	1	2	2	47	50	52	62
AFT CROSS BEAM	9	13	12	10	72	76	66	78
DIAGONAL STRUT	-8	-5	-5	2	21	20	16	29
ET/SRB AFT ATTACH	77	52	100	120	-203	-210	-160	-160
CABLE TRAY COVER	12	28	8	13	87	96	92	95

3.5.3 COMPARTMENT AND COMPONENT TEMPERATURES - Maintaining required nose cone and I/T compartment gas temperatures is a primary concern only during prelaunch operations. Minimum compartment temperature requirements are established to preclude ice/frost formations at vent areas. This necessitates temperature control starting before cryo load and continuing through to liftoff. Maximum nose cone gas temperature is limited by the LSC located in the LO2 cable tray next to the nose cone purge line. Maximum I/T gas temperature is limited initially by electrical component limits and then by structural temperature gradients at liftoff. Just prior to liftoff, conditioning purges were terminated causing compartment gas temperatures to decrease continuing into flight. The gas is vented to a reducing atmosphere and is virtually gone after 130 seconds into flight.

Components within the compartments are qualified and calibrated corresponding to given compartment temperature ranges.

For a properly maintained prelaunch compartment gas temperature, decrease in gas temperature during flight has a very small effect on components because of the short time involved. Components have an appreciable thermal capacitance and are able to retain the majority of the stored thermal energy through ET separation preventing component temperatures from decreasing below minimum specified operating limits.

Components external to the compartments are thermally isolated from cryogens and/or aeroheating environments in order to maintain required operating temperatures. These components, by design, have a wider operating range and are not as sensitive to changes in temperature.

A summary of compartment and component temperatures is presented in Table 3.5.3-1. I/T gas temperature decreased as predicted and component temperatures remained at or near liftoff values. As expected, reference temperatures for instrument islands increased during ascent. For the feedline fairing, temperature decreased because of cold I/T gas venting over the calorimeter base. Nose cone gas temperature is not recorded during flight.

TABLE 3.5.3-1 COMPARTMENT AND COMPONENT TEMPERATURES

COMPARTMENT/COMPONENT	TEMPERATURE T-9M TO T-0	TEMPERATURE CHANGES DURING FLIGHT
AADS BRACKET (DEG-F)	136 - 141	DECREASED TO 129
NOSE CONE GAS (DEG-F)	86 - 89	NOT MEASURED
RSS PANEL GAS (DEG-F)	42 - 44	DECREASED TO 9
INTERTANK GAS (DEG-F)	43 - 51	DECREASED TO 5
LO2 C/T ODNANCE (DEG-F)	87	DECREASED TO 81
LH2 C/T ODNANCE (DEG-F)	67	DECREASED TO 56
CALORIMETER REF TEMP (DEG-F)		
BOLT CATCHER	66	INCREASED TO 97
FEEDLINE FAIRING	50	DECREASED TO 43
LO2 OGIVE ISLAND * 2	59	INCREASED TO 93
INTERTANK ISLAND *17	71	INCREASED TO 100
LH2 BARREL ISLAND *35	17	INCREASED TO 55
AFT DOME ISLAND *46	43	INCREASED TO 108

3.6.0 ELECTRONICS AND INSTRUMENTATION

3.6.1 BUS B VOLTAGE AND DFI VOLTAGE - The main Bus B voltage limits are 26 to 32 Vdc and the DFI Bus voltage limits are 24 to 32 Vdc. As can be seen in Figure 3.6.1-1 both of these voltages were within limits during the period of -600 seconds to +600 seconds.

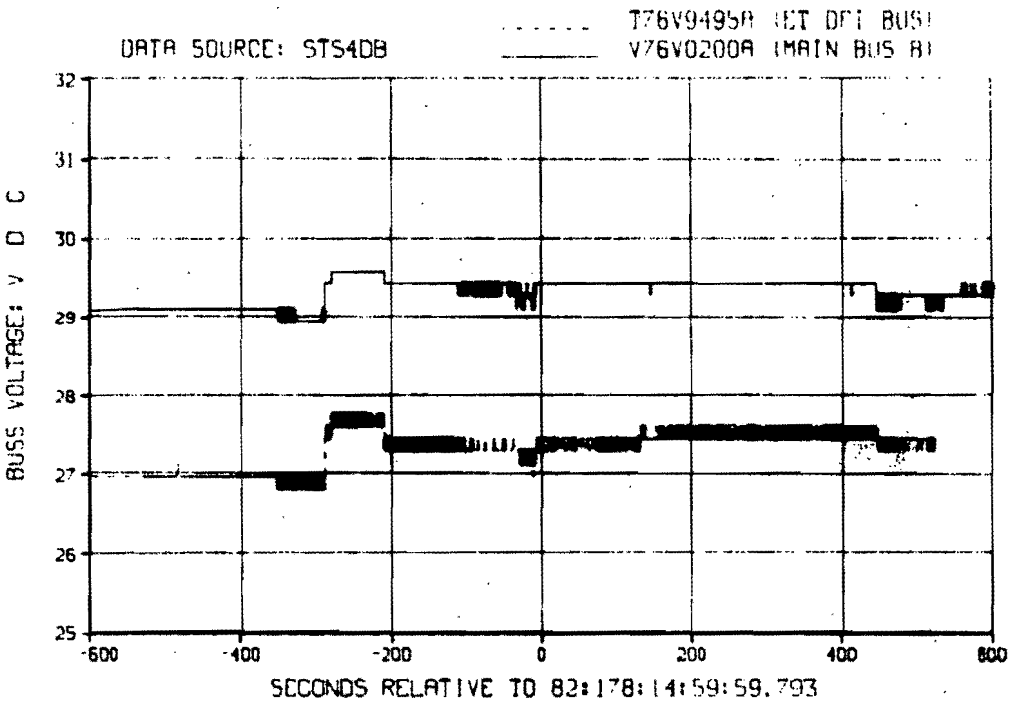


FIGURE 3.6.1-1 BUS VOLTAGE

3.6.2 INSTRUMENTATION PERFORMANCE - Based upon total measurements of OI, DFI/PCM and DFI/FM, data return was 97.8%. Based upon measurements available for flight, data return was 98.7%. The LO2 and LH2 ullage pressure measurements are illustrated in Figures 3.6.2-1 and 3.6.2-2 for the entire test period and Figures 3.6.2-3 and 3.6.2-4 for the prepressurization through flight period. All pressures tracked each other within the required accuracy.

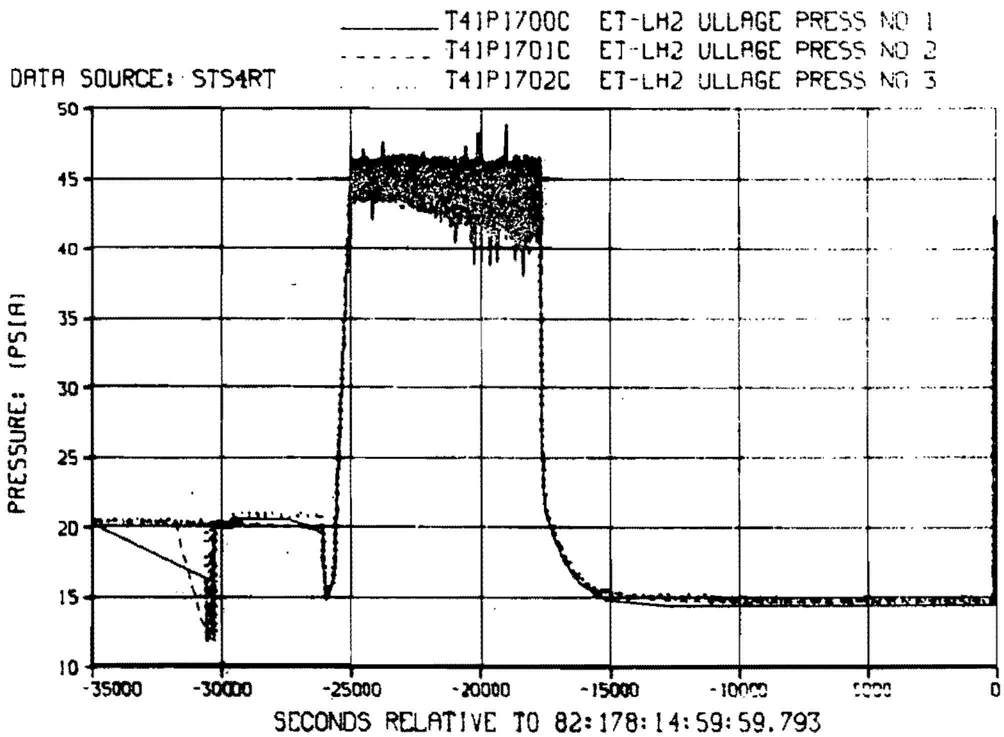


FIGURE 3.6.2-1 ET-LH2 ULLAGE PRESSURE

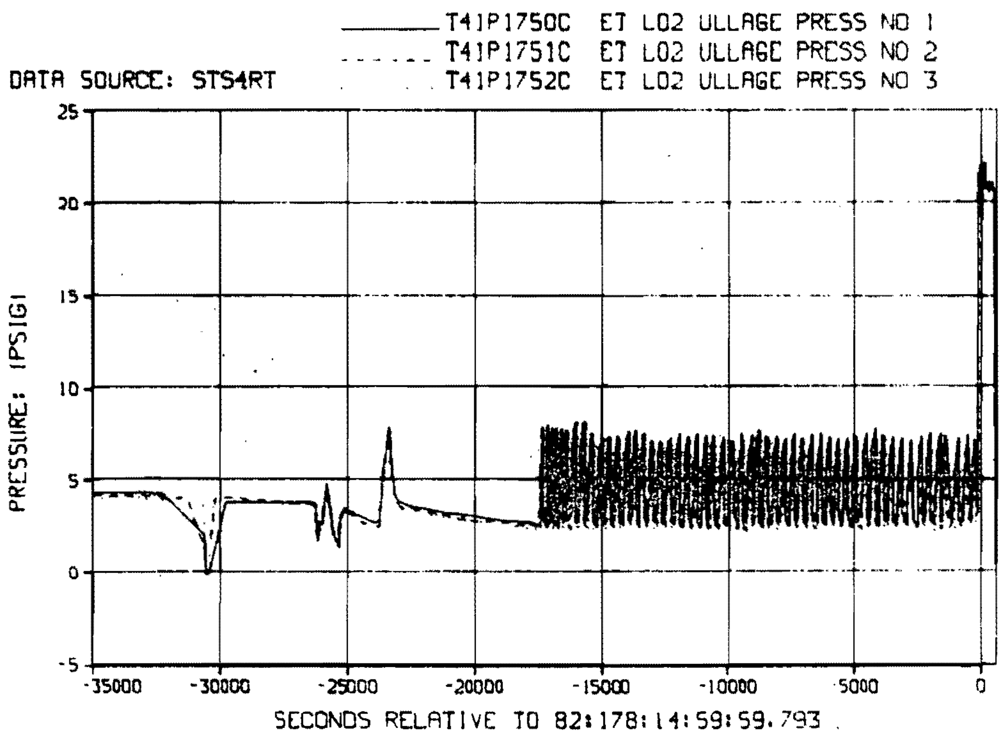


FIGURE 3.6.2-2 ET-LO2 ULLAGE PRESSURE

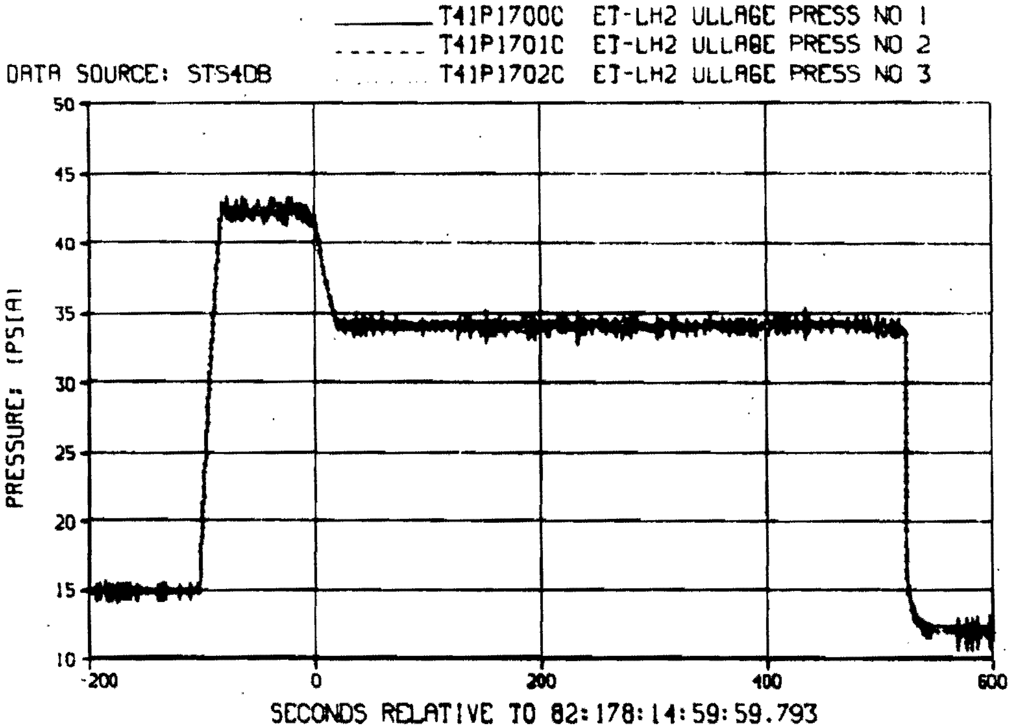


FIGURE 3.6.2-3 ET-LH2 ULLAGE PRESSURE

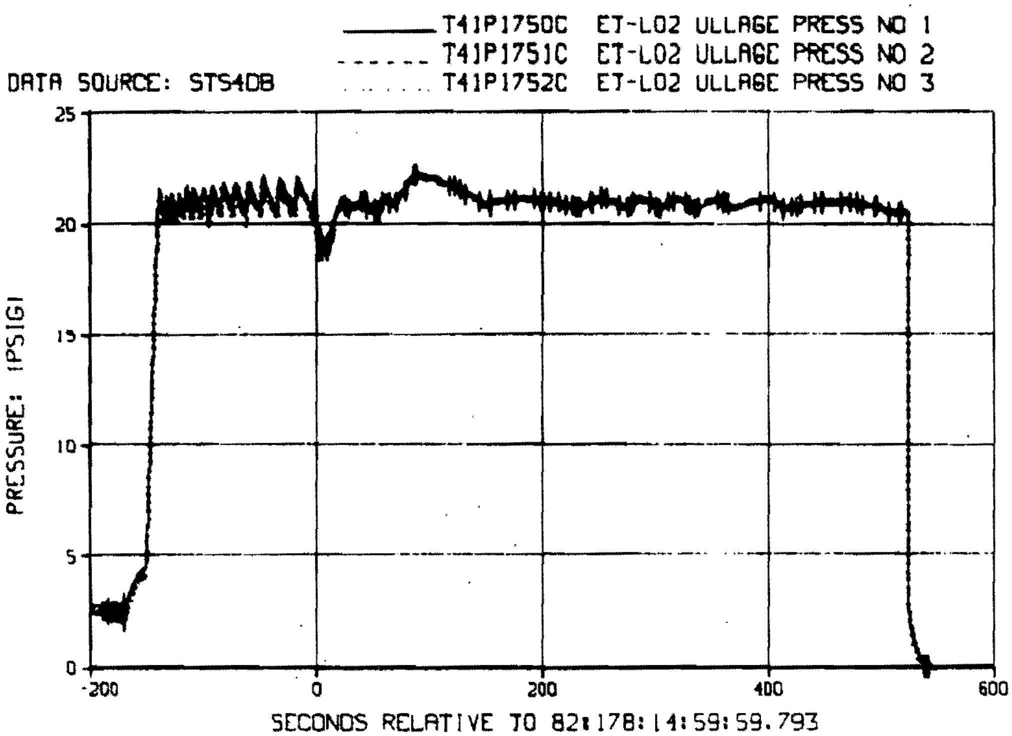


FIGURE 3.6.2-4 ET-LO2 ULLAGE PRESSURE

Table 3.6.2-1 summarizes the OI Instrumentation. There were no anomalies. Four of the liquid level sensors were not connected to recording channels and no data were available. Data from the two spare ullage sensors were not recorded.

TABLE 3.6.2-1 ET OI MEASUREMENTS

TYPE	TOTAL	WAIVED PRIOR TO STS-4	ANOMALIES STS-4	PARTIALLY VALID	NO DATA	ACCEPTABLE DATA
VENT VALVE	3	0	0	0	0	3
ULLAGE TEMP	2	0	0	0	0	2
ULLAGE PRESSURE	8	0	0	0	2*	6
ECO	8	0	0	0	0	8
TUMBLE VALVE	1	0	0	0	0	1
LIQUID LEVEL	24	0	0	0	4*	20
GROUND TEMP	6	0	0	0	0	6
GROUND PRESSURE	2	0	0	0	0	2
TOTALS	54	0	0	0	6	48

*INSTRUMENTS NOT CONNECTED.

TOTAL DATA RETURN - 48/48 - 100%
FLIGHT DATA RETURN - 48/48 - 100%

Table 3.6.2-2 summarizes the DFI/PCM Instrumentation and Table 3.6.2-3 summarizes the DFI/FM Instrumentation. Tables 3.6.2-4 and 3.6.2-5 list the anomalies, probable causes and planned actions or solutions for ET-5 and up.

TABLE 3.6.2-2 DFI PCM INSTRUMENTATION PERFORMANCE

TYPE	TOTAL	WAIVED/MRB'D PRIOR TO STS-4	ANOMALIES STS-4	PARTIALLY VALID	NO DATA	ACCEPTABLE DATA
HEAT FLUX	54	0	0	0	0	54
STRAIN	64	0	0	0	0	64
LIQUID LEVEL	10	0	0	0	0	10
CURRENT	4	0	0	0	0	4
PCM FIXED RESISTOR	1	0	0	0	0	1
PCM MUX BITE	16	0	0	0	0	16
BUS VOLTAGE	2	0	0	0	0	2
PRESSURE	45	T07P9559A T07P9568A	0	0	0	45
TEMPERATURE	102	T41T9048A T09T9665A T09T9626A T09T9615A T07T9051A T09T9634A T41T9034A	T41T9029A	T41T9029A	T41T9048A T09T9665A T09T9626A T09T9615A	97
TOTALS	298	9	1	1	4	293

TOTAL DATA RETURN - 293/298 - 98.3%
FLIGHT DATA RETURN - 293/294 - 99.7%

TABLE 3.6.2-3 OFI/FM INSTRUMENTATION PERFORMANCE

	TOTAL	WAIVED PRIOR TO STS-4	ANOMALIES STS-4	PARTIALLY VALID	NO DATA	ACCEPTABLE DATA
POGO PRESSURE	6	0	T41P9993A	C	T41P9993A	5
VIBRATION, LOW FREQUENCY	21	0	0	0	0	21
VIBRATION, HIGH FREQUENCY	31	0	T08D9261A T08D9262A	T08D9C61A	T08D9262A	29
ACOUSTICS	8	0	T08Y9956A	T08D9956A	0	7
TOTALS	66	0	4	2	2	62

TOTAL DATA RETURN - 62/66 - 94.0%
FLIGHT DATA RETURN - 62/66 - 94.0%

TABLE 3.6.2-4 STS-4 ET OFI PCM INSTRUMENTATION PERFORMANCE

ET-4 PROBLEM	PROBABLE CAUSE	PLANNED ACTION/SOLUTION ET-5 AND UP
3 STICK ON TYPE TEMPERATURE SENSOR FAILED DURING TANKING PHASE (T09T9665A, T09T9626A, T09T9615A)	TEMPERATURE CYCLING OPENED SENSOR ELEMENT OR CONNECTION WITHIN THE SENSOR. CAUSE OF FAILURE (SENSOR OPENING) IS NOT KNOWN. HIGH FAILURE RATE ON STS-1 AND STS-2 WAS DUE TO IMPROPER CYCLING DURING A.T.P. NO FAILURES ON STS-3.	A REVIEW OF FAILED SENORS REVEALED THAT ALL HAVE BEEN CYCLED CORRECTLY. NO PLANNED ACTION AT PRESENT - THESE FAILURES ARE CONSIDERED RANDOM FAILURES.
GO2 ORIFICE INLET TEMPERATURE FAILED AFTER TANKING TEST BUT PRIOR TO FLIGHT (T41T9048A)	FAILED HIGH INDICATING AN OPEN SENSOR OR CIRCUIT OR INCREASED RESISTANCE IN CIRCUIT.	SINCE THIS TYPE OF SENSOR IS USED IN 31 LOCATIONS ON THE ET AND THIS IS THE FIRST FAILURE SINCE SFII, IT IS CONSIDERED A RANDOM FAILURE WITH NO FURTHER ACTION PLANNED.
LH2 TANK BOTTOM LIQUID TEMPERATURE FAILED HIGH FOR APPROXIMATELY 60 SECONDS DURING FLIGHT (T41T9029A)	INTERMITTENT OPENING IN SENSOR OR CIRCUIT CAUSED A HIGH TEMPERATURE INDICATION	SINCE THIS TYPE OF SENSOR IS USED IN 31 LOCATIONS ON THE ET AND THIS IS THE FIRST FAILURE SINCE SFII, IT IS CONSIDERED A RANDOM FAILURE WITH NO FURTHER ACTION PLANNED.
NOSE CAP INTERNAL PRESSURE INDICATED LOW APPROXIMATELY 1.6 PSIA (Y07P9559A)	REFERENCE CHAMBER APPARENTLY LEAKED SUFFICIENTLY TO BIAS OUTPUT BY 1.6 PSIA. DATA WAS USEFUL AFTER ADDING BIAS. ONLY DATA LOSS OCCURRED AT 0 TO 1.6 PSIA. THIS MEASUREMENT HAD BEEN WAIVED BUT WAS CONSIDERED OK DURING FLIGHT.	SINCE DATA COULD BE SHIFTED TO RESULT IN ACCEPTABLE DATA THERE IS NO FURTHER ACTION PLANNED OTHER THAN REPEAT THIS CORRECTION IN THE EVENT OF A SIMILAR ANOMALY.
GAS TEMPERATURES ON AFT LH2 DOME CONSIDERABLY LOWER THAN PREDICTED (T07T9225A, T07T9226A, T07T9227A, T07T9228A, T07T9229A)	THERMOCOUPLE TEMPERATURE SENSOR 74L1-1 USED ON ET-3 & ET-4 APPARENTLY DOES NOT HAVE FRE-QUENCY RESPONSE NOR CAPABILITY OF MEASURING THE BOUNDARY LAYER GAS TEMPERATURES IN THE RARIFIED ATMOSPHERE AT ALTITUDE.	SRB'S FACING SAME PROBLEM. A SMALLER THERMOCOUPLE CAPABLE OF MEASURING UP TO 2600 F WAS EVALUATED ON STS-4 SRB. DUE TO LOSS OF SRB'S DATA HAS NOT BEEN RECOVERED. WILL CONTINUE TO USE PRESENT SENSORS.

TABLE 3.6.2-5 STS-4 ET DFI FM INSTRUMENTATION PERFORMANCE

ET-4 PROBLEM	PROBABLE CAUSE	PLANNED ACTION/SOLUTION ET-5 AND UP
LOWER FEEDLINE POGO PRESSURE APPEARED DEAD. (T41P9993A)	OPEN CIRCUIT POSSIBLY COAX CONNECTOR CENTER PIN OR WIRE.	LARGER PINS USED WHERE INSPECTION SHOWS SPREAD FEMALE CONTACT ON TRANSDUCERS.
FORWARD LH2 TANK INPUT TO GH2 PRESSLINE, NORMAL APPEARED DEAD. (T08D9262A)	OPEN CIRCUIT POSSIBLY COAX CONNECTOR CENTER PIN.	LARGER PINS USED WHERE INSPECTION SHOWS SPREAD FEMALE CONTACT ON TRANSDUCERS.
FORWARD LH2 TANK INPUT TO GH2 PRESSLINE, LONG APPEARED NOISY. (T08D9261A)	NOISY CIRCUIT POSSIBLY DUE TO COAX CONNECTOR CENTER PIN.	LARGE PINS USED WHERE INSPECTION SHOWS SPREAD FEMALE CONTACT ON TRANSDUCER.
AM AFT LH2 BULKHEAD. (T08Y9956A)	WATER IN TRANSDUCER.	MSFC INITIATED AN ECR TO MODIFY TRANSDUCER.

4.0 SPACE SHUTTLE MAIN ENGINES EVALUATION - This section presents the evaluation results for the three Space Shuttle Main Engines (SSME) during the flight of STS-4.

4.1.0 SSME FLIGHT SUMMARY - This subsection provides a summary of the more significant STS-4 evaluation results relative to the SSMEs.

4.1.1 SSME STS-4 OBJECTIVES AND ACCOMPLISHMENTS - Table 4.1.1-1 summarizes the STS-4 objectives pertaining to the SSMEs along with the degree of accomplishment and discrepancies for each objective.

TABLE 4.1.1-1 SSME OBJECTIVES AND ACCOMPLISHMENTS

OBJECTIVES	DEGREE OF ACCOMPLISHMENT	DISCREPANCIES
VERIFY THE OPERATIONAL CHARACTERISTICS OF THE SSMEs	COMPLETE	NONE
PROVE SSMEs AS INSTALLED OPERATE PER STANDARD	COMPLETE	NONE
VERIFY SSMEs FOR STS-5	COMPLETE	ME-3 HPFTP REPLACEMENT

4.1.2 SSME CONFIGURATION DEFINITION SUMMARY - The SSME uses a staged combustion cycle in which propellants are partially burned at low mixture ratio, high pressure, and relatively low temperature in the preburners and then completely burned in the main combustion chamber. The SSME flow schematic at rated power level is shown in Figure 4.1.2-1. The propellant system uses four turbopumps. The two low pressure turbopumps operate at relatively low NPSP to permit low pressures in the vehicle tanks. The function of these pumps is to provide sufficient pressure at the inlets of the high pressure turbopumps to permit them to operate at high speeds. Approximately 75% of the flow from the High Pressure Oxidizer Turbopump (HPOTP) goes directly to the main combustion chamber. Approximately 10% is directed to the preburner pump, which raises the pressure to that required by the preburners. Small quantities are bled through the heat exchanger for oxidizer tank pressurization and POGO suppression pressure. The balance of the oxidizer drives the turbine powering the Low Pressure Oxidizer Turbopump (LPOTP) and is then recirculated to the inlet of the HPOTP.

Approximately 20% of the High Pressure Fuel Turbopump (HPFTP) discharge flow is used to cool the Main Combustion Chamber (MCC), drive the low pressure fuel turbopump turbine, cool the hot-gas manifold and injector, and provide fuel tank pressurant. The remaining fuel is first used to cool the nozzle, and then to supply the preburners.

The hydrogen-rich steam generated by the fuel and oxidizer preburners first drives the high-pressure pump turbines, and then flows to the main injector where it is mixed with additional oxidizer and fuel and is injected into the main combustion chamber.

The main injector is a baffled, coaxial-element injector, with dual faceplates that are transpiration-cooled by gaseous hydrogen. The gimbal bearing is bolted to the main injector and dome assembly and is the thrust interface between the engine and vehicle. It also enables the engine to be gimballed to provide pitch, yaw and roll control. The Main Combustion Chamber (MCC) consists of an internal coolant liner and an external structural jacket. The coolant liner has longitudinal channels to form a fuel-cooled, up-pass cooling circuit. The nozzle is bolted to the MCC and is constructed of tapered tubes reinforced by a structural jacket with insulated hatbands. The tubes provide an up-pass fuel coolant circuit that is supplied with hydrogen through three down-pass transfer ducts connected to the aft inlet manifold. The nozzle has an expansion ratio of 77.5.

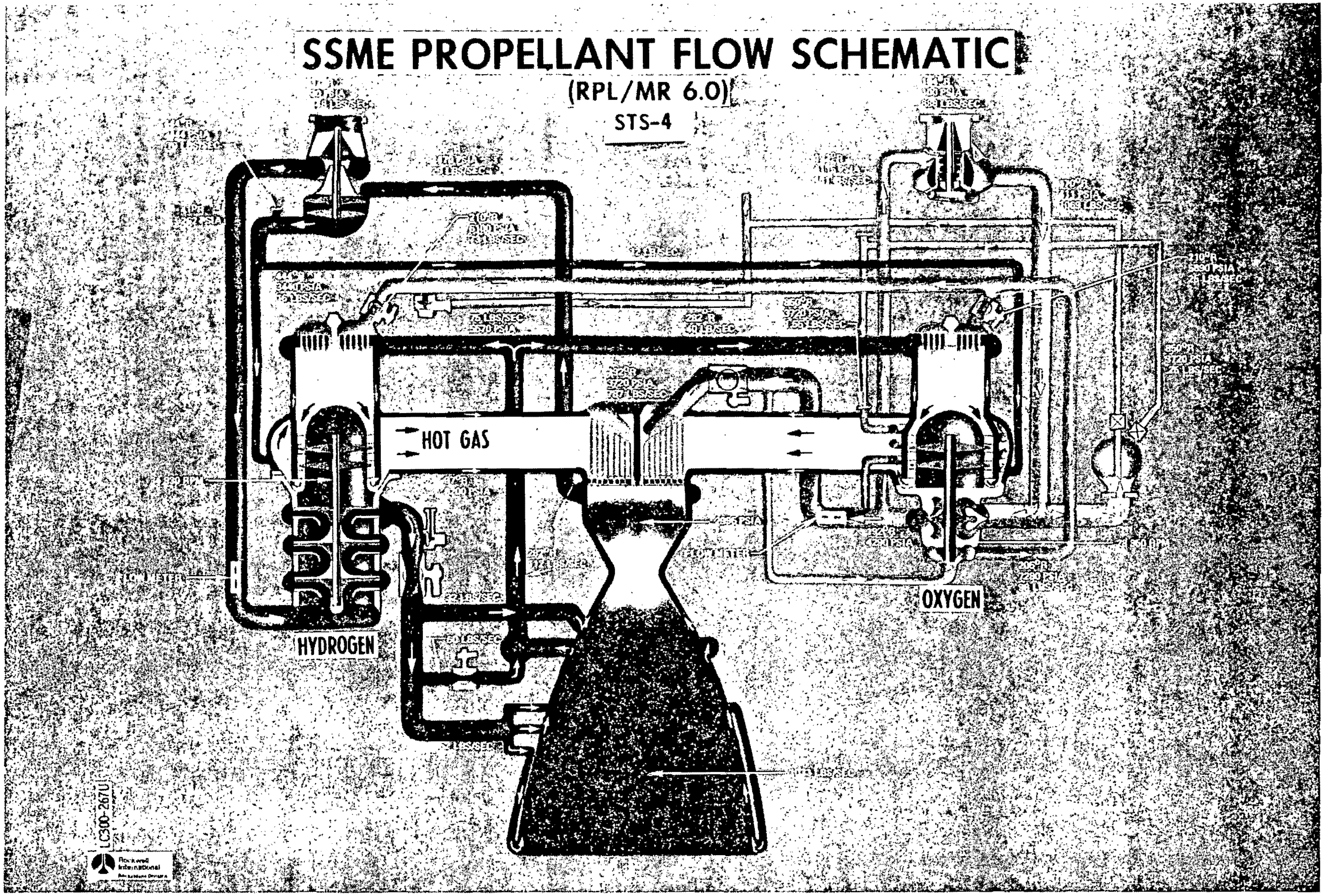


FIGURE 4.1.2-1 SSME PROPELLANT FLOW SCHEMATIC

The SSME engine is 167 inches tall. Its cross-sectional dimensions at the power head are 105 in. x 95 in. and the nozzle exit is circular with a diameter of 94 inches. The engine is designed to deliver a vacuum specific impulse of 454.4 seconds and have a life of 7.5 hours with 55 starts.

Table 4.1.2-1 provides the unit and serial numbers for SSME components used for the STS-4 flight. Table 4.1.2-1A shows hardware changes for STS-4.

TABLE 4.1.2-1 STS-4 SSME HARDWARE UNIT/SERIAL NUMBERS

	ENGINE 1 (UNIT 2007)	ENGINE 2 (UNIT 2006)	ENGINE 3 (UNIT 2005)
MAIN COMBUSTION CHAMBER	0009 /4881917	2006 /4104030	2005 /4104032
MAIN INJECTOR	2007 /4104037	2006 /4104025	9004 /4889614
NOZZLE	2007 /4886387	2005 /4887354	2006 /4887351
LOW PRESSURE OXIDIZER TURBOPUMP	2006 /4886830	2009 /4882206	2004 /4887683
HIGH PRESSURE OXIDIZER TURBOPUMP	0007R1/4884875	2004 /4886100	2005R1/4886099
LOW PRESSURE FUEL TURBOPUMP	2006 /4886875	2007 /4886347	0007 /4887903
HIGH PRESSURE FUEL TURBOPUMP	2009 /4881525	0306R2/4884626	0009R1/4882640
POWER HEAD	2007 /4886294	2006 /4887018	2005 /4103704
HEAT EXCHANGER	2006 /4911014	0005 /4911941	0008 /4889420
PNEUMATIC CONTROLLER	2007 /4913199	2006 /4887088	2005 /4887469
CONTROLLER	F6	F4	P7

TABLE 4.1.2-1A STS-4 SSME HARDWARE CHANGES UNIT/SERIAL NUMBERS

	ENGINE 1	ENGINE 2	ENGINE 3
LOW PRESSURE OXIDIZER TURBOPUMP		2009 /4882206 WAS 0008 /485693	
HIGH PRESSURE FUEL TURBOPUMP	2009 /4881525 WAS 9006R1/4888045	0306R2/4884626 WAS 0306R1/4884626	
CONTROLLER		F4 WAS F5	

4.1.3 <u>SSME FAILURES, ANOMALIES AND RECOMMENDED ACTION</u> - There were no significant anomalies that will impact the STS-5 mission associated with the SSMEs; there were two significant problems encountered which are described in Flight Test Problem Reports (FTPRs) in Figures 4.1.3-1 and 4.1.3-2.

FLIGHT TEST PROBLEM REPORT NO. MSFC-3

Statement of problem:

ME-3 (2005) HPFTP Impeller Damage Revealed During Post-flight STS-4 Hardware Inspection.

Discussion:

Post-flight disassembly and inspection of the ME-3 HPFTP revealed a 3/4" x 1/2" piece missing from the second stage impeller. The pump had been removed due to an excessive initial torque which exceeded the 370 in-lb specification value and excessive shaft travel. A review of the flight data did not reveal any significant changes in pump vibration or performance parameters, indicating that the failure probably occurred during engine shutdown. The cause of failure is impeller rubbing. This resulted in overheating and embrittlement of the titanium impeller teeth with subsequent cracking and propagation thereof by high cycle fatigue.

Required date for resolution: Prior to STS-5

Personnel assigned: G. Smith & R. Bledsoe/EE21 L.O. Wear 9/1/82

Action Progress:

A review of the FMOF development and certification test history (28 turbopumps and 116,000 seconds of total operation) revealed only one other instance of a failed impeller which was also discovered during post test inspections.

Effect on subsequent missions:

None

Conclusions:

The FMOF configuration is considered acceptable for the STS-5 flight based on the development and certification history of this design, the low probability of failure and the benignancy of the failure mode.

Corrective action:

ME-3 HPFTP (2005) was replaced with the space flight pump from engine 2009 per RAR (Rocketdyne Action Request) No. 213 "High Pressure Fuel Turbine Pump Changeout," dated July 27, 1982.

FIGURE 4.1.3-1 FLIGHT TEST PROBLEM REPORT - MSFC-3

Statement of problem: Sporadic MCC chamber pressure oscillations on ME-2 (2006) with controller F-4 during mainstage of STS-4.

Discussion: Sporadic oscillations in ME-2 main chamber pressure of ± 15 psi were noted during mainstage and ± 25 psi oscillations during maximum Q throttling with frequency range of approximately 2 Hz. The oscillations are not POGO instability but are control system related. The current controller F-4 was installed on ME 2006 for acceptance test and FRF. F-4 was replaced with controller F-5 prior to STS-1 due to a channel B failure. Controller F-4 was reinstalled on ME-2 after STS-3 and after correcting the channel "B" failure problem. No oscillations were observed on STS-1 thru STS-3. Oscillations have been noted on the current controller F-4 on three previous single engine tests and FRF. These oscillations have the same character as that noted on STS-4.

Possible causes of the oscillation are:

1. Digital/analog (D/A) failure resulting in valve position command deadband.
2. Servoamp electronics failure resulting in gain error, dead zone offset in the forward loop of the OPOV control.

Required date for resolution:
Prior to STS-5

Personnel assigned: L. Grant/EE21 & R. Bledsoe/EE21

Action Progress: Analysis of flight data has been completed. The control system gains have been assessed as well as all engine testing of the current controller F-4. The vehicle structures group have evaluated the oscillations for impact to the Orbiter structure by loads analysis. No detrimental effects are expected on STS-5 as result of this analysis.

Tests were conducted at the Huntsville Simulation Lab (HSL):

1. Simulating D/A failure with software patch in sampling/hold output.
2. Simulating forward loop gain error, dead zone and offset with breadboard circuit between controller and valve input.

Effect on subsequent missions:

STS-5

Conclusions: The oscillations experienced on STS-4 are not anticipated to have any detrimental effects on the vehicle nor the engine control system. The controller anomaly has not changed over a three-year period as evidenced by review of all engine test data. There is no reason to believe the anomalous behavior will become more pronounced. The "latched-bit" is believed to be the cause, and is self-limiting. Engine performance with the controller (F-4) is acceptable for STS-5 flight. Controller should not be replaced for STS-5.

Corrective action:

DAR (Deviation Acceptance Request) SSME-N1409 will be submitted for STS-5.

APPROVED: L. O. Wear 9/15/82
L. O. Wear

FIGURE 4.1.3-2 FLIGHT TEST PROBLEM REPORT - MSFC-5

4.2.0 SSME PERFORMANCE - This section provides the evaluation of the SSMEs during the STS-4 flight.

4.2.1 START PREPARATION PHASE - The SSME system purges and propellant conditioning were performed in preparation for engine start. The start preparation phase consists of five functions. These functions are purge sequence 1 through 4 (PSN 1-4), and engine ready mode. PSN-1 initiates the oxidizer system and HPOTP intermediate seal gaseous nitrogen purge which inerts the oxidizer system. Also included is the continuous verification of propellant valve closed position by application of the vehicle pneumatic supply system. PSN-2 turns on the fuel system purge which inerts the fuel system and the continuation of PSN-1. PSN-3 prepares the engine for propellant loading by opening the oxidizer and fuel bleed valves. Each hour during PSN-3, the fuel system purge is turned on for three minutes. At T0-5 minutes the hydraulic system is pressurized to operational levels when the APUs are activated. PSN-4 (initiated at approximately T0-4 minutes), turns on the fuel system purge, switches valve actuators over from pneumatic to hydraulic system control, removes pneumatic shutdown pressure from the engine, opens the CCV and initiates engine ready monitoring. When engine ready for this flight was achieved, all launch commit criteria were met and confirmed to start.

The SSME controller and boattail purge system were activated to inert the boattail before propellant loading. The effect of propellant loading on the Aft Fuselage Center bulk air temperature is shown in Figure 4.2.1-1. The heated GN2 purge was activated prior to PSN-2 to insure that the engine remained dry during propellant loading. The heated purge was maintained for 30 to 45 minutes at approximately 130 deg F (Figure 4.2.1-1A). The onboard hydraulic system was activated for engine actuators warmant flow during chill (Figure 4.2.1-2). Engine chilldown was normal. Bleed valve and POGO recirculation isolation valve operation were as planned. The cycling of the engine bleed valve (Figures 4.2.1-3 through 5) assurred the collapse of the GO2 bubble that may occur in the low pressure oxidizer duct during chilldown. Engine ready was achieved when all conditions of the launch commit criteria were met (Table 4.2.1-1). Figures 4.2.1-6 through 9 show the propellant conditions at engine ready.

Pneumatic and purging functions were normal. The fuel system purge (Figure 4.2.1-10) was initiated every 60 minutes throughout chill and continuously at PSN-4 (Figure 4.2.1-11) to ensure a dry inert environment downstream of the engine main fuel valve. Switchover from GN2 to helium for purging of the HPOTP intermediate seal was accomplished at PSN-4 and verified to meet the minimum limit of 170 psia (Figure 4.2.1-12). The engine GN2 purge supply was terminated at PSN-4 and the fuel and oxidizer preburner purge pressures decayed below the maximum allowable value of 50 psia (Figure 4.2.1-13). The emergency shutdown pneumatic pressure was removed at PSN-4 and verified to be below the maximum of 50 psia (Figure 4.2.1-14), as required.

Hydraulic operations during start preparation were as predicted. The warmant flow mode was conducted at approximately 500 psia supply pressure (Figure 4.2.1-2) and MFV actuator heater operation was normal throughout chill. The three Orbiter APU hydraulic systems were activated at T0-5 minutes to provide 3200 psia supply pressure to the SSMEs (Figure 4.2.1-15). Subsequently the MFV and MOV actuator outlet temperatures met the engine ready requirements during PSN-4 (Figures 4.2.1-16 and 17).

Valve and turbomachinery liftoff seal leakage monitoring verified nonleaking conditions through the start preparation phase. The MFV and OPOV line skin temperature measurements met all required limits (Figures 4.2.1-18 through 21).

The engine controller thermal environment was maintained within required limits (PSN-4) for both the power supply and the input electronics (Figure 4.2.1-22). Actuator operations at all positions were normal during the start preparation (Table 4.2.1-1).

An overall summary of prestart requirements is found in Table 4.2.1-1 for MEC monitored parameters and Table 4.2.1-2 for the observer LPS monitored parameters.

TABLE 4.2.1-1 SSME LAUNCH COMMIT CRITERIA PRESTART
MEC MONITORED

PARAMETER	STS-4 CRITERIA VALUE	STS-4 CRITERIA MONITOR PERIOD		STS-4 VALUES ME-1	STS-4 VALUES ME-2	STS-4 VALUES ME-3
ENGINE STATUS WORD	'ENGINE READY'	PRIOR TO GLS AUTO START (T-31 SEC) TO START CMD		-79.6	-79.6	-80.1
PROPELLANT CONDITIONS						
LPFP DISCH PR, PSIA	47-61	'FOR ENG READY'	MIN	50.9	51.0	51.5
			MAX	52.5	52.9	53.1
LPFP DISCH T,R	42 MAX	'FOR ENG READY'		38.9	39.3	39.1
LPOP DISCH PR, PSIA	95-600	'FOR ENG READY'	CH A	99.2	107.0	107.8
				104.3	110.9	112.9
			CH B	100.1	105.3	107.9
				105.2	109.1	113.0
PBP DISCH T,R	178 MAX	'FOR ENG READY'	CH A	171.6	171.4	173.0
			CH B	171.7	171.5	173.2
PRESSURES						
OPB PURGE,PSIA	50 MAX	'FOR ENG READY'	OXID	14.0	14.7	18.3
FPB PURGE,PSIA			FUEL	14.7	14.7	14.6
EMERG S/D PURGE,PSIA	50 MAX	'FOR ENG READY'	CH A	14.7	15.0	19.2
			CH B	14.5	11.5	15.2
FUEL SYSTEM PURGE,PSIA	200 MIN	'FOR ENG READY'	CH A	322.0	338.8	344.7
			CH B	322.2	337.5	344.5
HPOP IMSL PURGE,PSIA	170 MIN	'FOR ENG READY'	CH A	195.9	204.3	187.6
			CH B	194.6	203.6	187.6
POGO PRECHARGE, PSIA	600-1425	START -2.54 TO -2.48 (FROM ME-3)	CH A	710.2	724.7	714.6
			CH B	710.9	720.1	714.6
TEMPERATURES						
MOV HYDRAULIC, DEG R	495 MIN	'FOR ENG READY'	CH A	563.9	556.6	552.6
			CH B	562.9	555.6	555.7
MFV HYDRAULIC, DEG R	495 MIN	'FOR ENG READY'	CH A	563.4	553.7	552.0
			CH B	564.6	557.2	553.4
HPFT DISCH T, DEG R	700 MAX	'FOR ENG READY'	CH A	464.5	467.3	461.4
			CH B	462.4	459.2	461.0
HPOT DISCH T, DEG R	700 MAX	'FOR ENG READY'	CH A	468.7	464.7	470.3
			CH B	474.8	460.6	475.5
VALVE POSITIONS						
MAIN PROPELLANT VALVES,%	6 MAX	'FOR ENG READY'	MOV	-.12	-.56	-1.4
			MFV	-.62	-1.16	-.98
			OPOV	-.04	-.11	-.42
			FPOV	.85	-.44	-.17
			CCV	-.52	-.03	-.67
HEX ANTI-FLOOD VALVES,%	10 MAX	'FOR ENG READY'	CH A	-1.18	-1.73	-1.96
			CH B	- .96	-1.29	- .85
FUEL/OXID BLEED VALVES,%	80 MIN	'FOR ENG READY'	FUEL	102.1	104.3	106.0
			OXID	106.5	101.2	105.3
	20 MAX	'FOR ENG READY'	FUEL	.36	-.96	-.41
			OXID	.81	-.52	- .85
*POGO RECIRC VALVE,%	20 MAX	'FOR ENG READY'		2.12	3.38	4.14
	80 MIN	'FOR ENG READY'		102.3	94.0	104.1

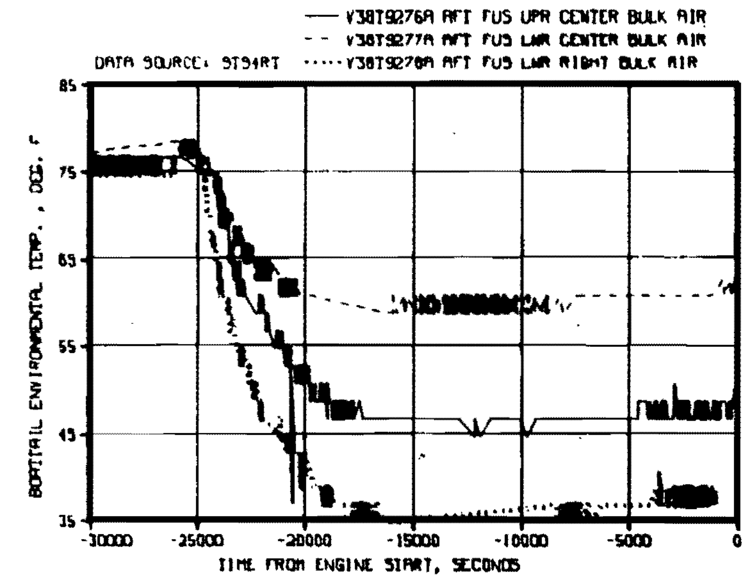


FIGURE 4.2.1-1 BOATTAIL ENVIRONMENTAL TEMPERATURE

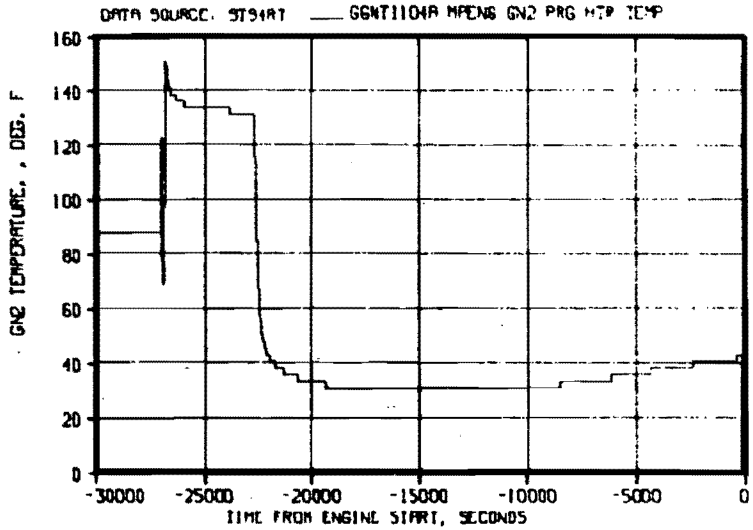


FIGURE 4.2.1-1A GN2 PURGE TEMPERATURE

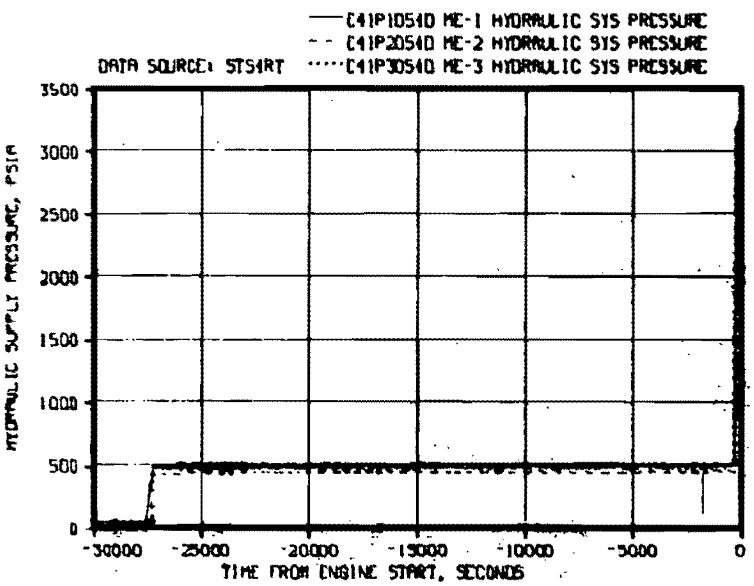


FIGURE 4.2.1-2 HYDRAULIC PRESSURE DURING START PREP.

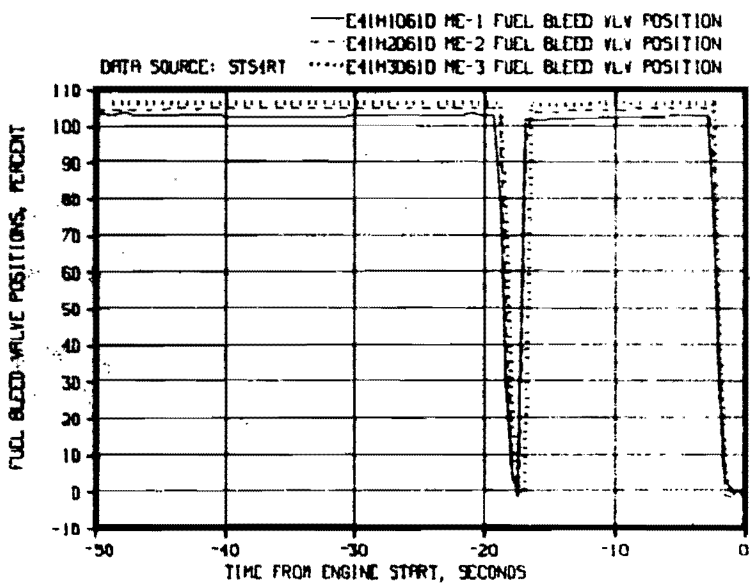


FIGURE 4.2.1-3 FUEL BLEED VALVE POSITION DURING START PREP.

4.2-3

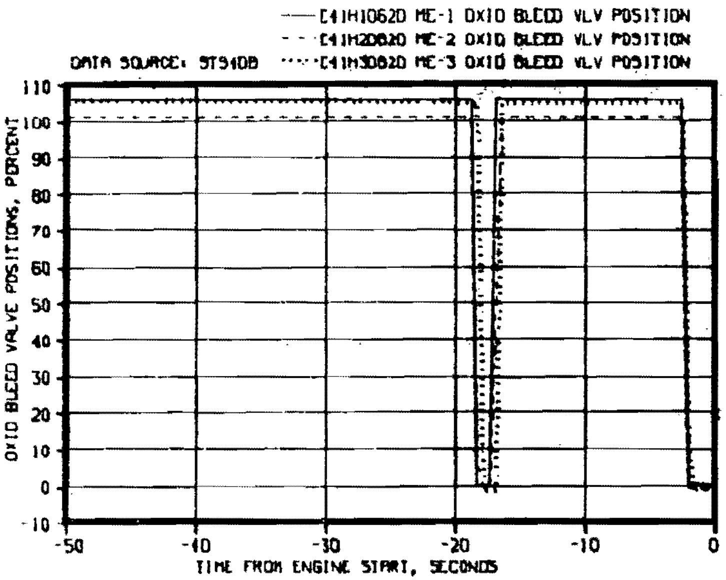


FIGURE 4.2.1-4 OXID BLEED VALVE POSITION DURING START PREP.

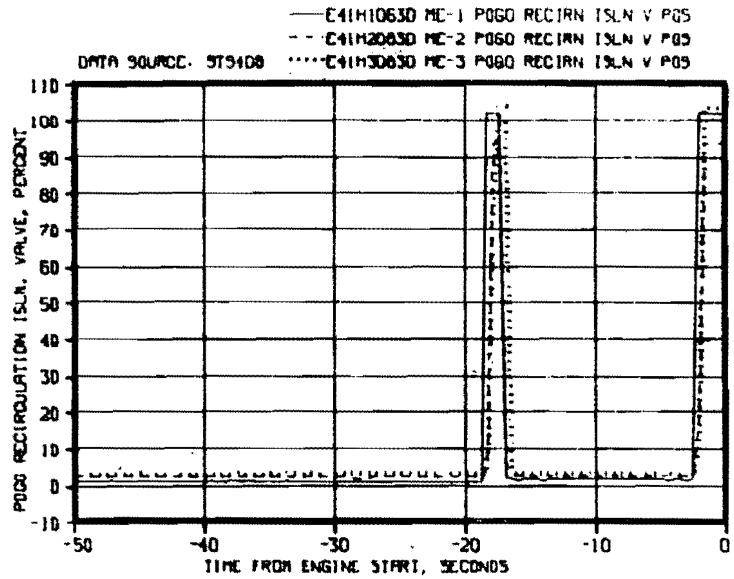


FIGURE 4.2.1-5 POGO RECIRN ISLN VALVE POSITION DURING START PREP.

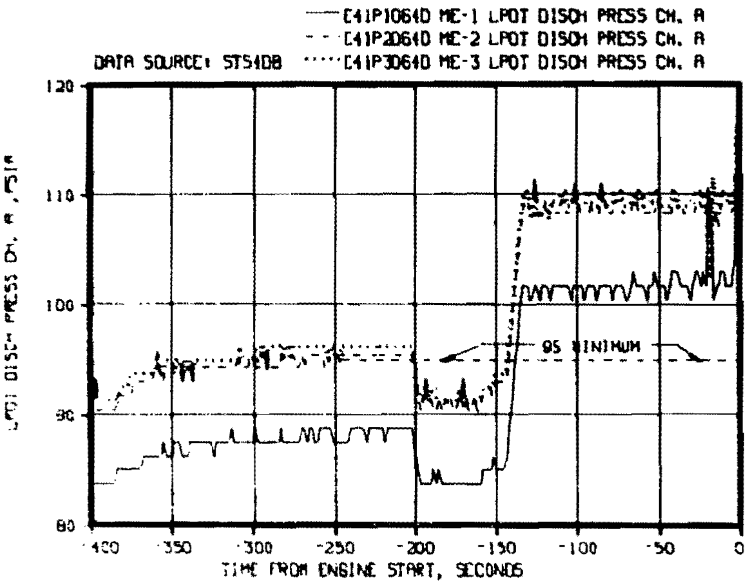


FIGURE 4.2.1-6 LPOT DISCHARGE PRESSURE DURING START PREP.

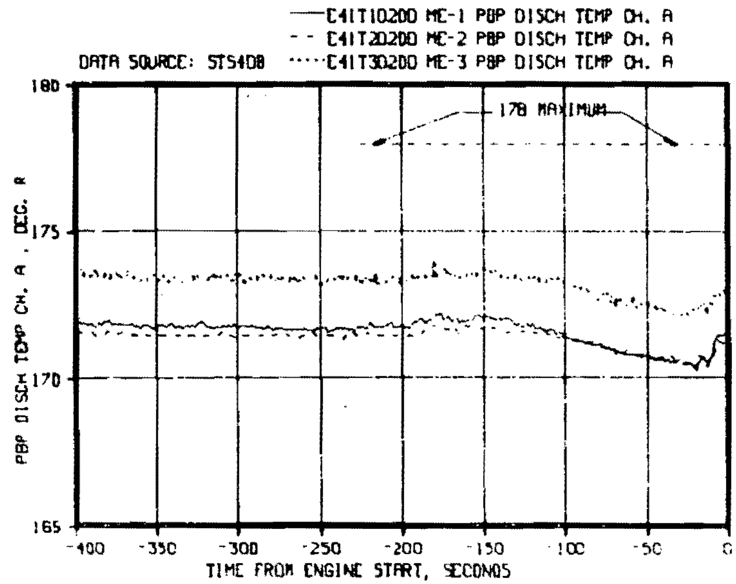


FIGURE 4.2.1-7 PREBURNER DISCHARGE TEMPERATURE DURING START PREP.

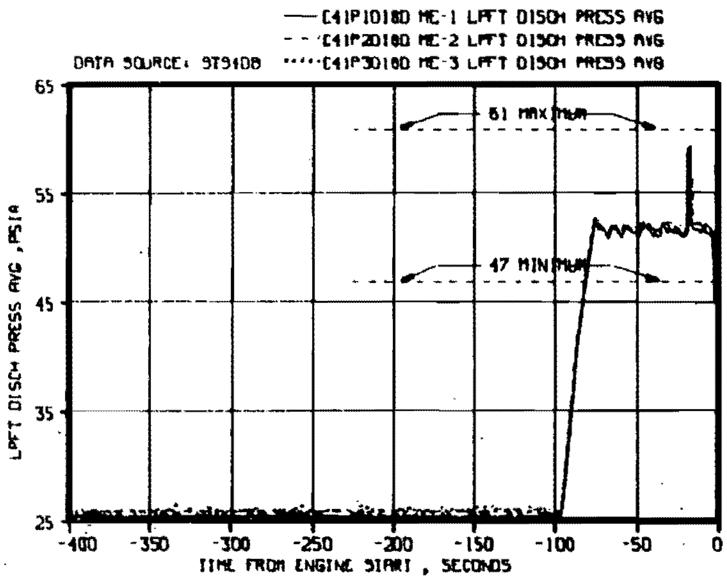


FIGURE 4.2.1-8 LPFT DISCHARGE PRESS DURING START PREP.

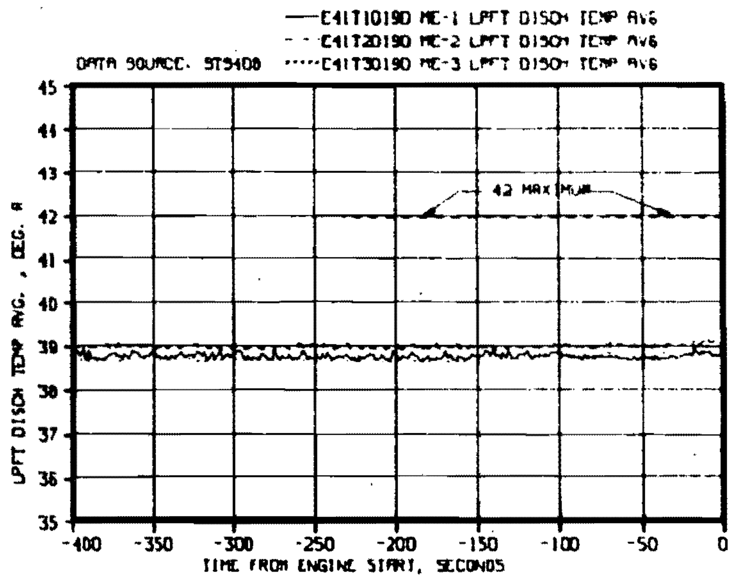


FIGURE 4.2.1-9 LPFT DISCHARGE TEMP DURING START PREP.

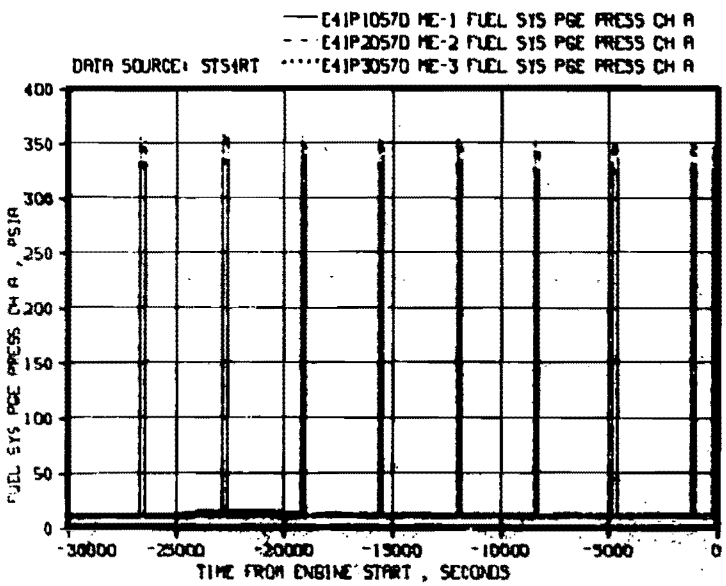


FIGURE 4.2.1-10 FUEL SYS PURGE PRESSURE DURING START PREP.

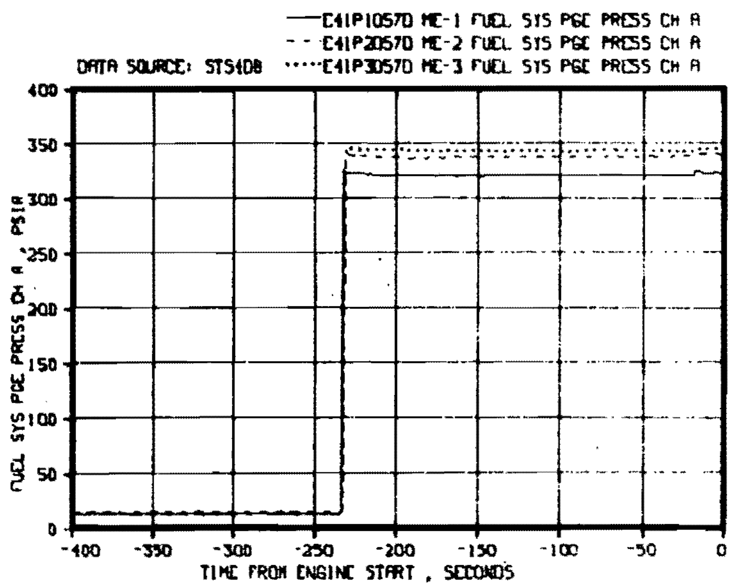


FIG 4.2.1-11 FUEL SYSTEM PURGE PRESSURE DURING START PREP.

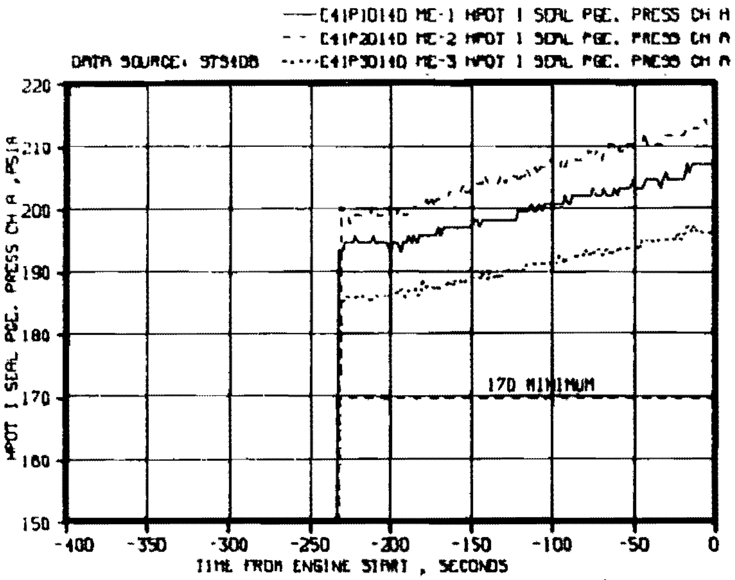


FIGURE 4.2.1-12 HPOT I SEAL PGE. PRESS DURING START PREPARATION.

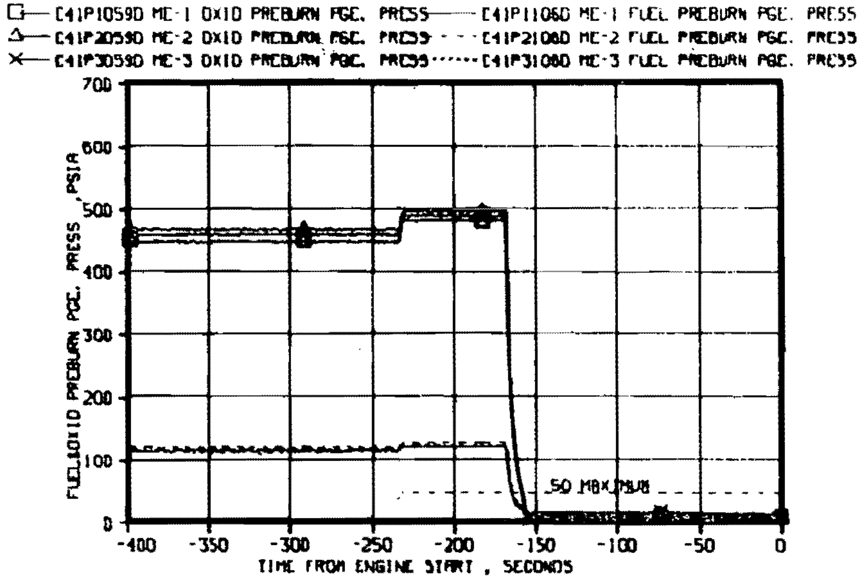


FIGURE 4.2.1-13 FUEL&OXID PREBURNER PGE. PRESS DURING START PREP.

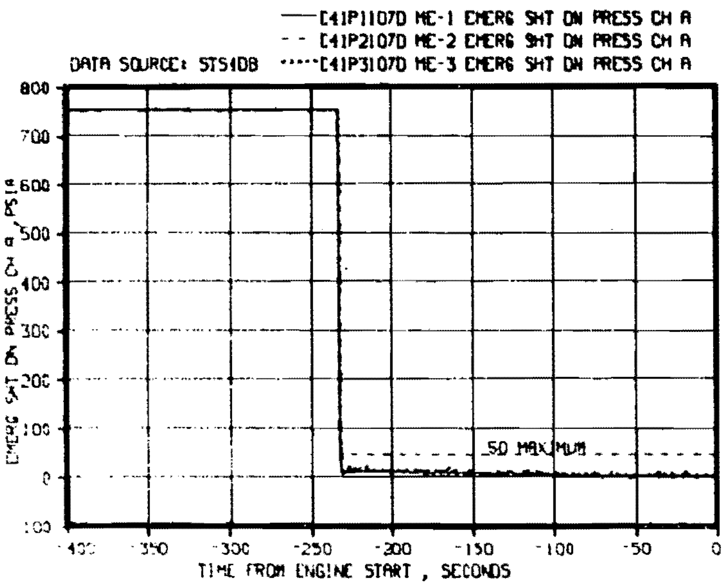


FIGURE 4.2.1-14 EMERG SHT DN PRESS DURING START PREPARATION.

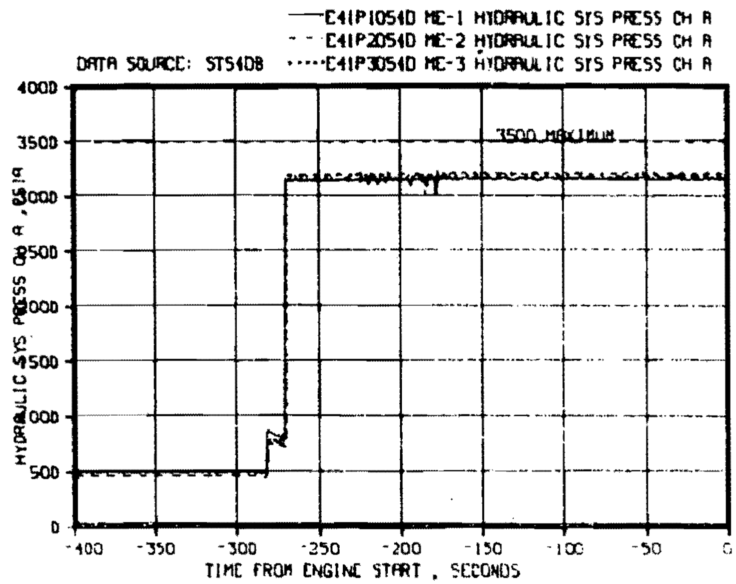


FIGURE 4.2.1-15 HYDRAULIC SYS PRESS DURING START PREPARATION.

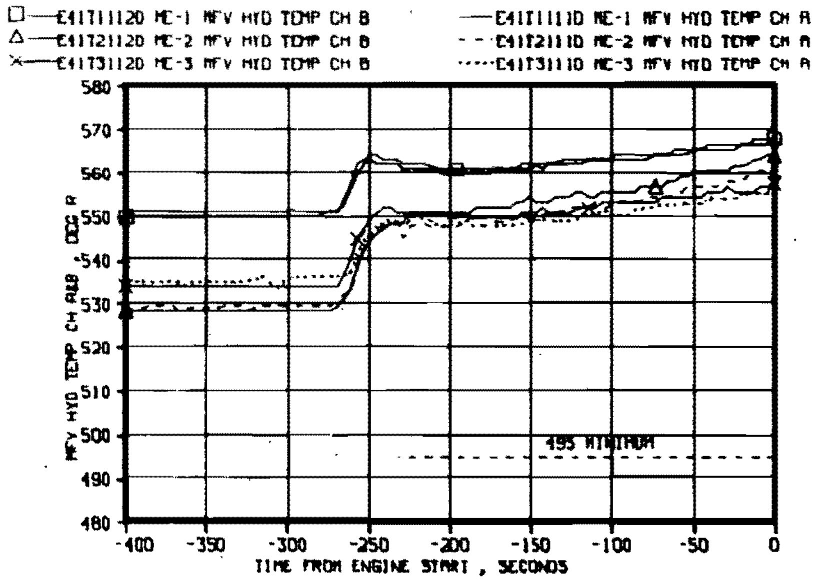


FIGURE 4.2.1-16 MAIN FUEL VALVE HYD TEMP. DURING START PREP.

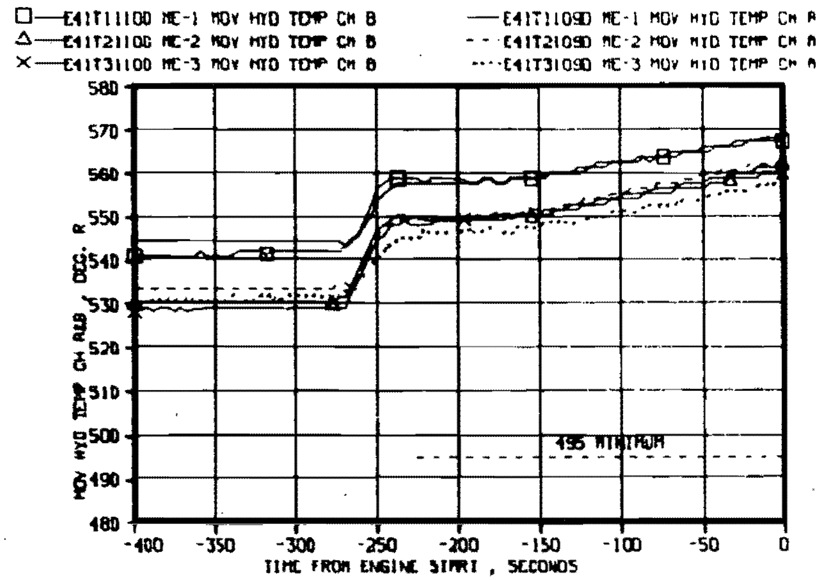


FIGURE 4.2.1-17 MAIN OXID VALVE HYD TEMP. DURING START PREP.

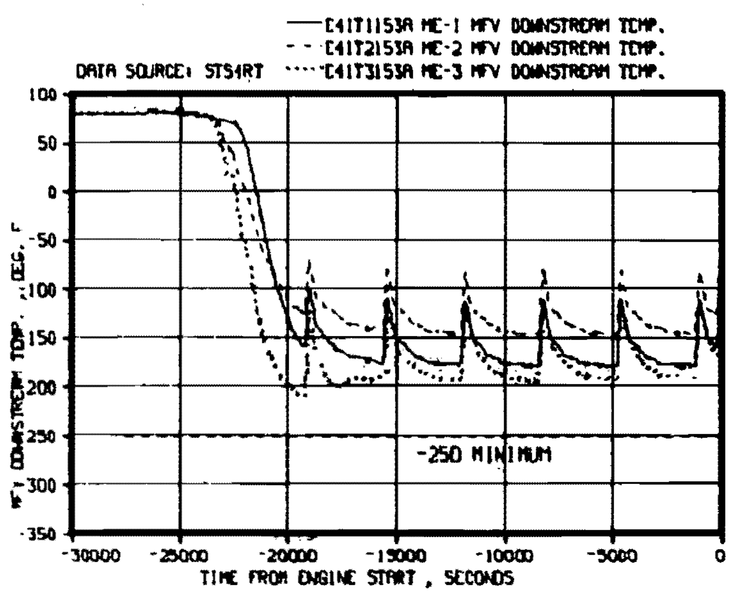


FIGURE 4.2.1-18 MFV DOWNSTREAM TEMP. DURING START PREP.

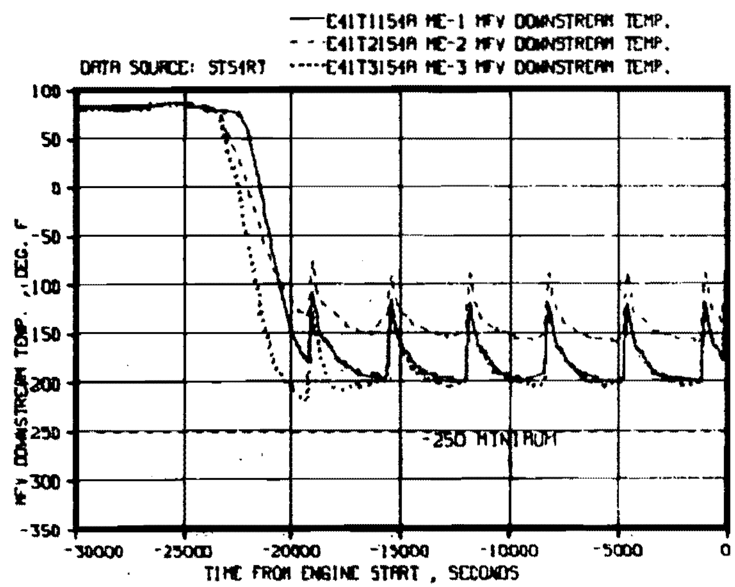


FIGURE 4.2.1-19 MFV DOWNSTREAM TEMP. DURING START PREP.

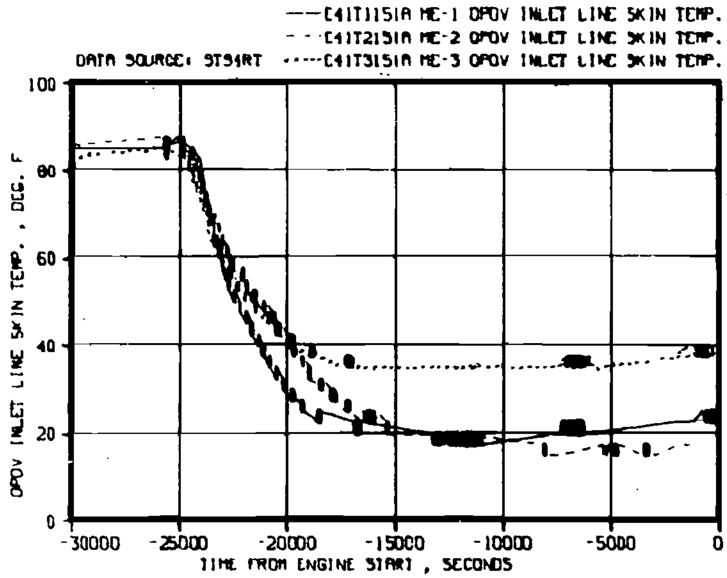


FIGURE 4.2.1-20 OPOV INLET LINE SKIN TEMP. DURING START PREP.

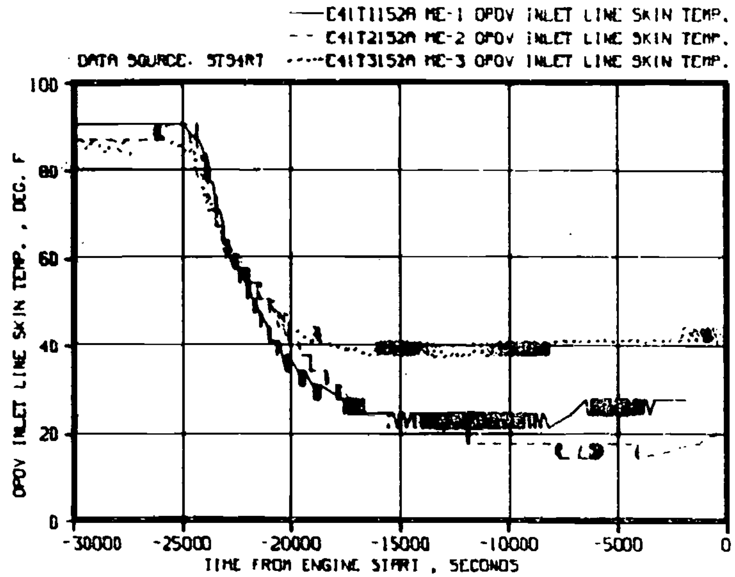


FIGURE 4.2.1-21 OPOV INLET LINE SKIN TEMP. DURING START PREP.

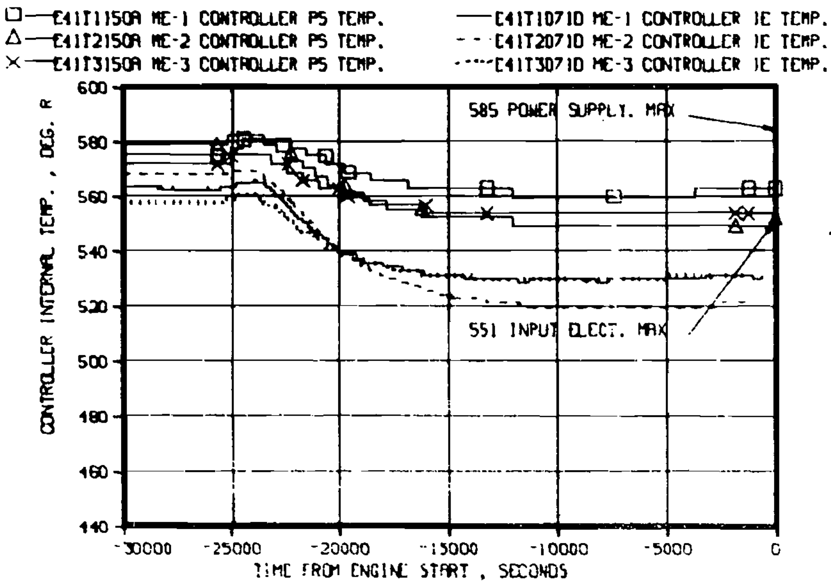


FIGURE 4.2.1-22 CONTROLLER INTERNAL TEMPERATURES DURING START PREP.

TABLE 4.2.1-2 SSME LAUNCH COMMIT CRITERIA PRESTART OBSERVER/LPS MONITORED

PARAMETER	STS-4 CRITERIA VALUE	STS-4 CRITERIA MONITOR PERIOD		STS-4 VALUES ME-1	STS-4 VALUES ME-2	STS-4 VALUES ME-3
PRESSURES						
HYDRAULIC SUPPLY, PSIA						
ENGINE	2700 MIN	T-243 SEC		3163.	3197.	3193.
ORBITER	2800-3400	T-243 SEC -SRB IGN	MIN MAX	3093. 3152.	3135. 3221.	3088. 3178.
		T-165 TO T-31	MIN MAX	3120. 3136.	3168. 3184.	3120. 3136.
TEMPERATURES						
OPOV INLET LINE, DEG R	300 MIN	CRYO LOAD TO T-31 SEC,	CH A CH B	478. 481.	475. 475.	495. 498.
MFV OUTLET LINE, DEG R	210 MIN	CRYO LOAD TO T-31 SEC,	CH A CH B	282. 283.	314. 303.	251. 240.
HPFT DISCH, DEG R	360 MIN	CRYO LOAD TO T-31 SEC,	CH A CH B	463. 467.	464. 463.	463. 469.
MEC INPUT ELECT, DEG R	551 MAX	CRYO LOAD TO T-31 SEC,		532.*	522.*	532.*
MEC POWER SUPPLY, DEG R	585 MAX	CRYO LOAD TO T-31 SEC,		563.*	553.*	554.*

* TAKEN AT T-31 SECONDS

4.2.2 START PHASE – The engine start command was accepted by ME-3 at 6.559 seconds prior to T-0 (SRB Ignition Command). ME-2 and ME-1 start followed at 0.133 and 0.246 seconds respectively after ME-3 start as planned. All three engines were started to RPL and all valve opening positions and rates were nominal.

Power level transients for the three engines, as shown in Figure 4.2.2-1, were similar to each other, agreed with predicted and fell within the ICD limits. Flight results are compared to ICD requirements in Table 4.2.2-1. All ICD requirements were met. A more detailed discussion of power level rise and propellant consumption during the start transient is given in section 5.4.1.

For the start phase, there are also several redline limits or gates monitored by the engine controller that the engine must meet or premature shutdown will result. These redlines are shown in Tables 4.2.2-2 and 4.2.2-3 with actual values noted for the MEC monitored and the GPC monitored parameters. The margins on all limits were satisfactory and no anomalies were noted. The actual engine operating conditions are shown plotted versus these limits in Figures 4.2.2-2 through 7. Figure 4.2.2-2 shows the HPFP speed buildup with the 4600 RPM minimum gate noted. Figure 4.2.2-3 shows the ignition confirmed Pc limits at 2.34 seconds versus the actual engine start transients. The 90 percent Pc minimum check is also shown on this graph. The HPOT discharge temperature limits and engine start transients are shown in Figure 4.2.2-4. The HPFT discharge temperature gate and engine values are shown in Figure 4.2.2-5. The POGO precharge pressure limits and antiflood valve position limits are shown in Figures 4.2.2-6 and 7, respectively.

An additional limit which results in a Major Component Failure (MCF) indication if exceeded is the OPOV position. A maximum commanded limit is included in the engine software and if the OPOV commanded position exceeds this limit for 60 msec continuously after 5.0 seconds, an MCF will be indicated. If this occurs prior to SRB ignition, the Orbiter will issue an engine shutdown command. The OPOV position limits and actual valve positions are shown in Figures 4.2.2-8 through 10 for ME-1, ME-2 and ME-3, respectively. These limits are set for approximately two percent margin. As noted, these limits were not exceeded.

Three software changes were incorporated to increase the margins and clarify posting of FIDs during the start transients. These changes were: (1) increase ME-3 OPOV open loop command to 48%; (2) increase actuation time of the HPOT Turbine Discharge MCF monitor from 3.5 to 3.8 seconds; and (3) fix for HPFT Turbine Discharge temperature prestart monitor. All of these changes produced satisfactory results.

TABLE 4.2.2-1 START TRANSIENT FOR STS-4 COMPARED TO ICD REQUIREMENTS

	ICD REQUIREMENTS	ME-1	ME-2	ME-3
ENGINE START (GMT) (1) (82:178:14:59)		:53.480	:53.367	:53.234
COMMANDED POWER LEVEL	NONE	RPL	RPL	RPL
TIME FROM ENGINE START TO STEADY-STATE (2) (SEC)	3.73 to 5.00	4.16	4.16	4.28
TIME FROM ENGINE START TO COMMANDED MR (3) (SEC)	5.5 (MAX)	3.44	3.76	3.84
ENGINE START RATE				
THRUST RISE RATE TO 15% RPL (LBS/0.01 SEC)	20,000 (MAX)	5428.	8145.	5349.
THRUST RISE RATE AFTER 15% RPL (LBS/0.01 SEC)	7,000 (MAX)	3751.	3922.	5826.
THRUST RISE RATE AFTER 20% RPL (LBS/0.5 SEC)	175,000 (MAX)	136,916.	137,005.	137,702.
ENGINE PROPELLANT CONSUMPTION (4)				
TOTAL (LBS)	1025/1725 (MIN/MAX)	1445.	1452.	1554.
OXIDIZER (LBS)	830/1380 (MIN/MAX)	1185.	1178.	1280.
FUEL (LBS)	195/345 (MIN/MAX)	260.	274.	280.

(1) BASED ON INITIAL MOVEMENT OF MFV POSITION COMMAND
(2) DEFINED AS TIME TO COMMANDED THRUST LEVEL +/- 6000 LBS.
(3) DEFINED AS TIME FOR MIXTURE RATIO TO ENTER THE +/- 1% TOLERANCE BAND AVERAGED OVER 500 MS.
(4) PROPELLANT USED UP TO STEADY STATE AS DEFINED IN (2).

TABLE 4.2.2-2 SSME LAUNCH COMMIT CRITERIA PRE-SRB IGNITION-MEC MONITORED

PARAMETER	STS-4 CRITERIA VALUE	TIME FROM START, SEC		STS-4 VALUES ME-1	ME-2	ME-3
START CONFIRM						
PC & FUEL FLOW VALID	LOSS OF INPUT	0-2.3		OK	OK	OK
HPFP SPEED, RPM	4600 MIN	1.24-1.28		6073.	6873.	6704.
MCC PC, PSIA	610-1000	2.3 -2.34		805.	814.	814.
ANTI-FLOOD POS,%	80 MIN	2.3 -2.34	CH A	103.	101.	102.
			CH B	102.	101.	103.
HPFT DISCH TEMP, DEG R	810-1960	4.50-4.54	CH A	1576.	1599.	1666.
			CH B	1638.	1639.	1671.

TABLE 4.2.2-3 SSME LAUNCH COMMIT CRITERIA PRE-SRB IGNITION-GPC MONITORED

PARAMETER	STS-4 CRITERIA VALUE	STS-4 CRITERIA TIME FROM START, SEC	STS-3 VALUES ME-1	STS-3 VALUES ME-2	STS-3 VALUES ME-3
ENGINE STATUS WORD					
PHASE	START/ MAINSTAGE	0 - SRB IGN	ST/MS	ST/MS	ST/MS
MAJOR COMPONENT FAILURE					
POGO PRECHARGE, PSIA	600 MIN	2.60 - 4.40	714.	728.	715.
POGO GO2 FLOW, PSIA	800-1445	4.94 - 4.98	1202.	1274.	1159.
LOSS OF REDUNDANCY	ENG OK	0 - SRB IGN	ENG OK	ENG OK	ENG OK
CONTROLLER	ENG OK	0 - SRB IGN	ENG OK	ENG OK	ENG OK
ACTUATOR	ENG OK	0 - SRB IGN	ENG OK	ENG OK	ENG OK
REDLINE	ENG OK	0 - SRB IGN	ENG OK	ENG OK	ENG OK
REDLINE LIMIT FAIL	ENG OK	0 - SRB IGN	ENG OK	ENG OK	ENG OK
OPOV CMD LIMITED	ENG OK	0 - SRB IGN	ENG OK	ENG OK	ENG OK
ELECTRICAL LOCKUP MODE	NORMAL CONTROL	2.3-SRB IGN	NORMAL	NORMAL	NORMAL
HYDRAULIC LOCKUP MODE	NORMAL CONTROL	0 - SRB IGN	NORMAL	NORMAL	NORMAL
MCC PC, PSIA	>90% RPL	4.6-SRB IGN	99.9	99.7	99.6
CMD/DATA PATH FAIL	PATH OK	0 - SRB IGN	OK	OK	OK

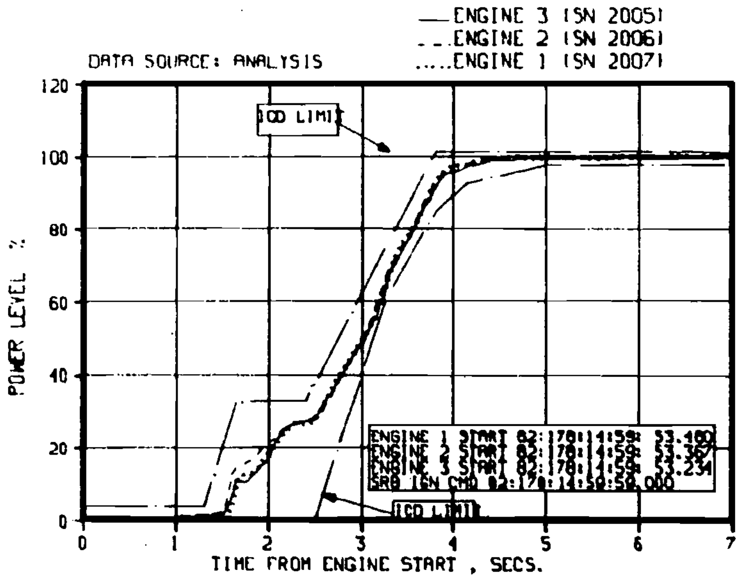


FIGURE 4.2.2-1 POWER LEVEL OF ENGINE 1,2 AND 3 COMPARED TO ICD REQUIREMENTS

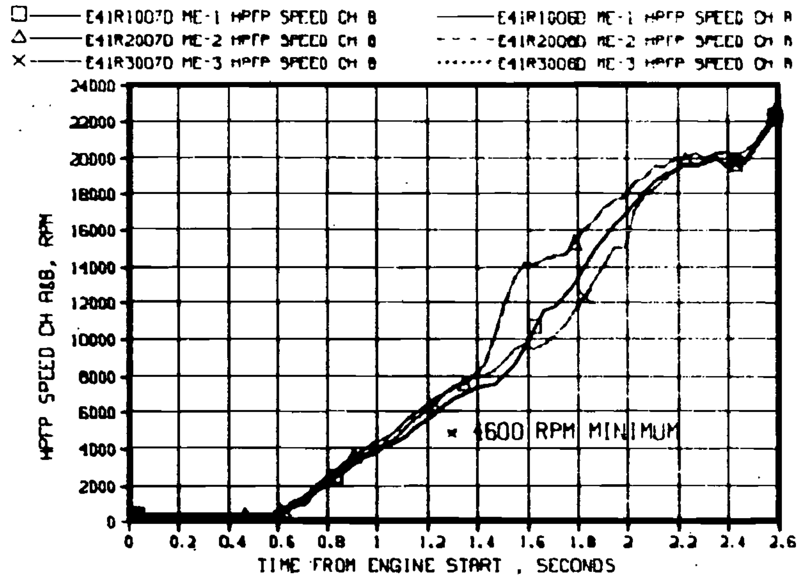


FIGURE 4.2.2-2 HPFP SPEED DURING START TRANSIENT

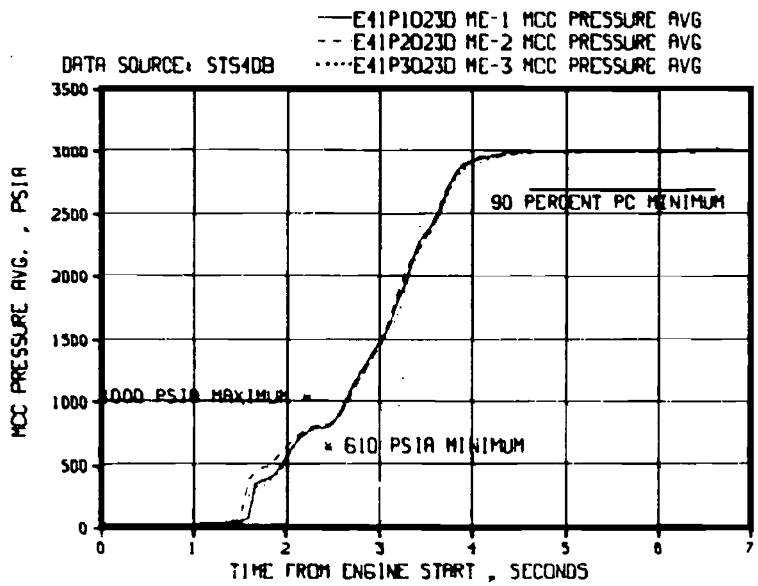


FIGURE 4.2.2-3 MAIN CHAMBER PRESSURE DURING START TRANSIENT

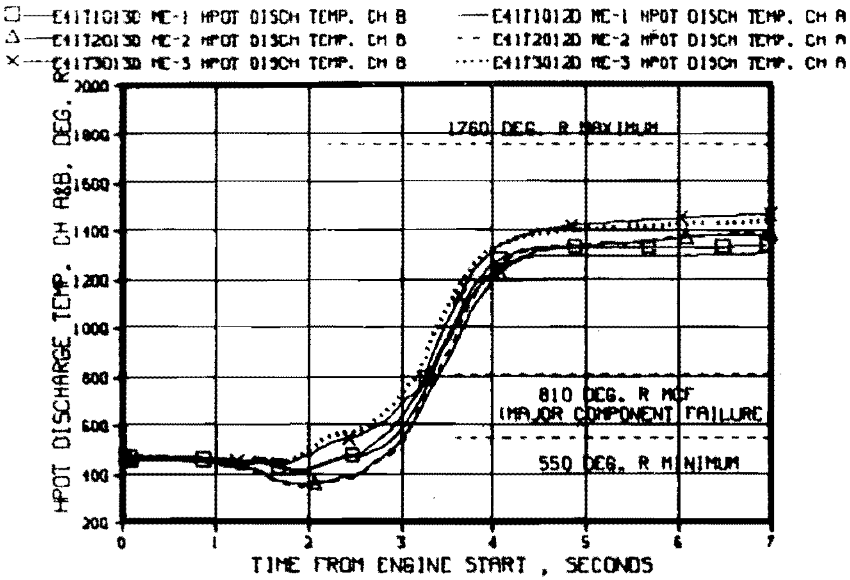


FIGURE 4.2.2-4 HPOT DISCHARGE TEMP. DURING START TRANSIENT

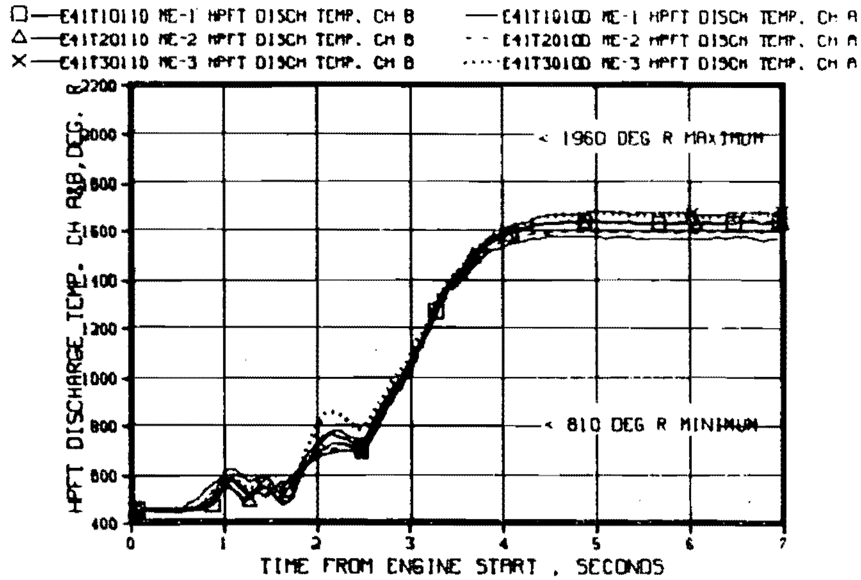


FIGURE 4.2.2-5 HPFT DISCHARGE TEMP. DURING START TRANSIENT

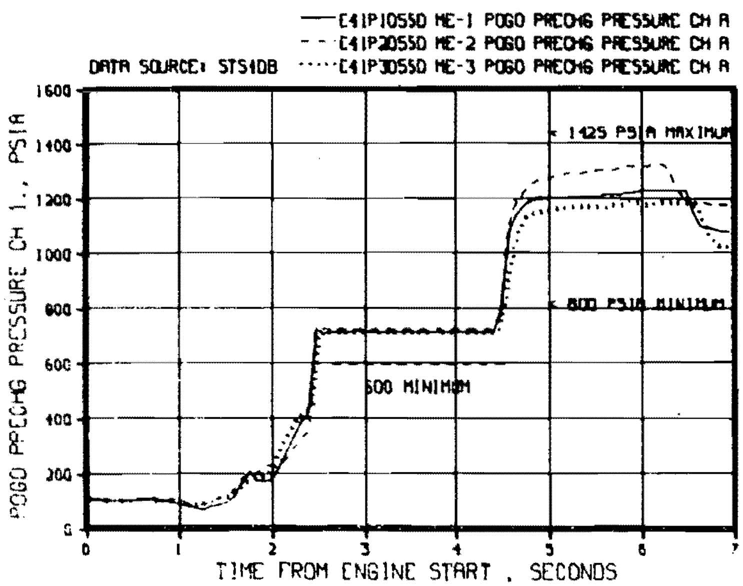


FIGURE 4.2.2-6 POGO PRECHARGE PRESSURE DURING START TRANSIENT

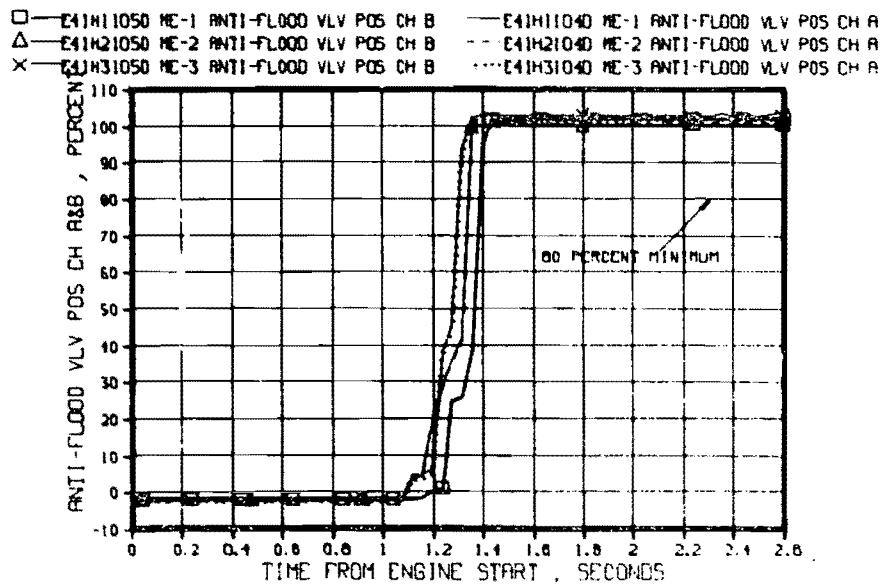


FIGURE 4.2.2-7 ANTI-FLOOD VALVE POSITION DURING START TRANSIENT

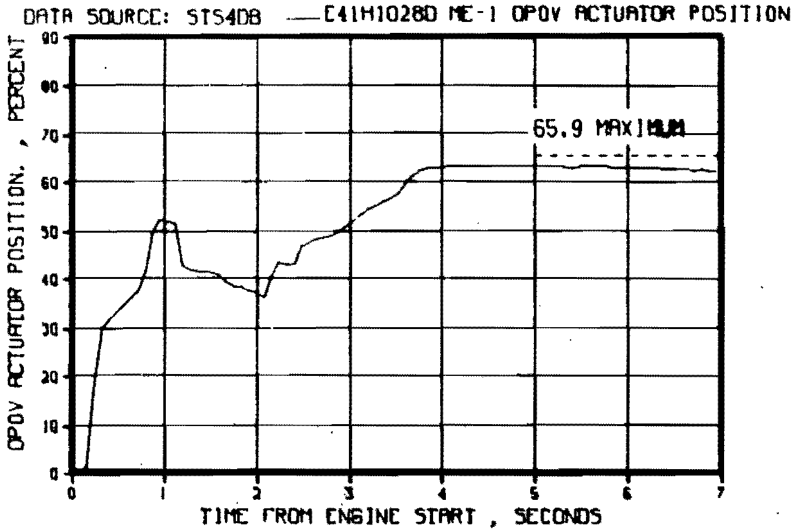


FIGURE 4.2.2-8 OPOV ACTUATION POSITION DURING START TRANSIENT

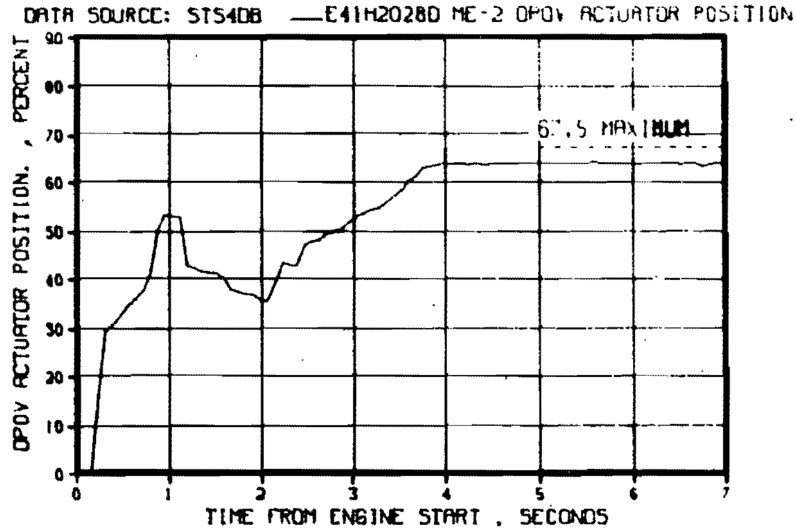


FIGURE 4.2.2-9 OPOV ACTUATION POSITION DURING START TRANSIENT

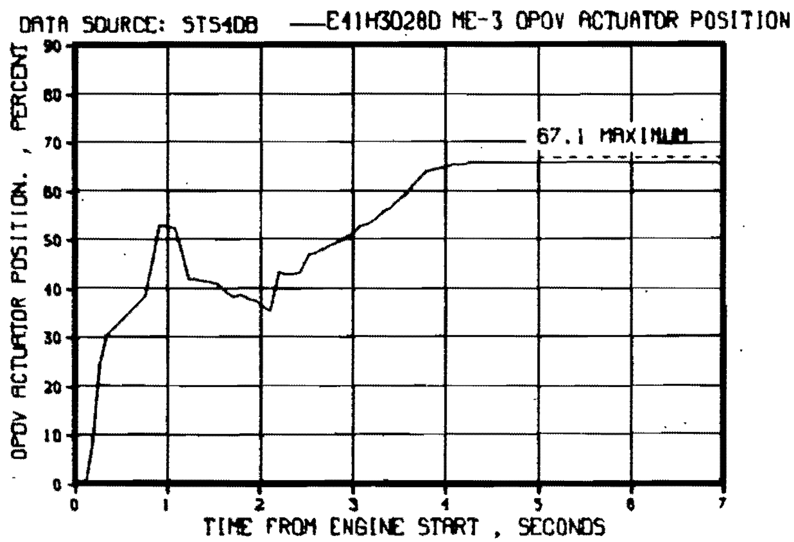


FIGURE 4.2.2-10 OPOV ACTUATION POSITION DURING START TRANSIENT

4.2.3 MAINSTAGE PHASE – Main chamber pressure and mixture ratio command levels were maintained throughout the entire flight. The main chamber pressure throttling for the three engines was normal (Figure 4.2.3-1). Significant event times during STS-4 mainstage operation are given in Table 4.2.3-1.

TABLE 4.2.3-1 SIGNIFICANT TIMES DURING STS-4*

ENGINE S/N	SRB IGNITION	MAX Q THROTTLE	REACHED 65%	THROTTLE UP	REACHED RPL	3G THROTTLE	REACHED 65%	MECO
ME-1 (S/N 2007)	6.31	43.12	46.12	57.20	60.70	464.80	513.20	519.03
ME-2 (S/N 2006)	6.43	43.20	46.70	57.30	60.80	464.90	513.40	519.15
ME-3 (S/N 2005)	6.56	43.28	46.85	57.45	60.95	464.00	513.50	519.31

*TIME FROM ENGINE START (SEC)

4.2.3.1 ENGINE OPERATIONS – Propellant interface conditions met requirements. The LO2 inlet pressure (Figure 4.2.3-2) reached a maximum value at SRB staging as expected. The oxidizer inlet temperature was within requirements and reflected little bulk temperature rise during flight (Figure 4.2.3-3). Engine fuel inlet pressure and temperature, shown in Figures 4.2.3-4 and 5, were all within requirements. Figures 4.2.3-6 and 7 summarize the oxidizer and fuel NPSP during the flight. These values were within the ICD limits. Helium interface conditions were met on all three engines. Figures 4.2.3-8 and 9 show that the hydraulic pressure and MOV/MFV hydraulic temperatures met all system requirements.

All mainstage redline requirements, summarized in Table 4.2.3-2, were met. The HPOT discharge temperature is shown in Figure 4.2.3-10, the HPOTP intermediate seal purge pressure is shown in Figure 4.2.3-11, the turbine secondary seal cavity pressure is shown in Figure 4.2.3-12, and the primary oxidizer seal drain pressure is shown in Figure 4.2.3-13. The controller redlines are also included on the charts to show operating margin. The redline value of 100 psia is not shown in Figure 4.2.3-12. The HPOTP seal package parameters all compared favorably to previous flight results. HPFTP turbine temperatures shown in Figure 4.2.3-14 were normal. The OPOV thrust limit margins, reflected in Figures 4.2.3-15 through 17, were within acceptable limits.

TABLE 4.2.3-2 STS-4 MAINSTAGE REQUIREMENTS

PARAMETER	REDLINE VALUE	TIME FROM ENGINE START (SECS)		STS-4 VALUE ME-1	ME-2	ME-3
HPOT DISCH TEMP,R	550 - 1760	2.30 - C/O,	CH A	1320.	1402.	1481
		(MAX)	CH B	1349.	1405.	1511.
		3.80 - C/O,	CH A	884.	962.	969.
		(MIN)	CH B	924.	964.	1010.
HPOP LO2 DRAIN PR, (PSIA)	45 MAX	START - C/O,	CH A	17.2	17.2	16.0
			CH B	17.2	16.6	15.4
POT SEC SL CAV PR, (PSIA)	100 MAX	START - C/O,	CH A	40.9	43.7	48.5
			CH B	40.7	43.8	49.1
HPOT IMSL PURGE PR, (PSIA)	170 MIN	START - C/O,	CH A	205.	213.	197.
			CH B	204.	213.	197.

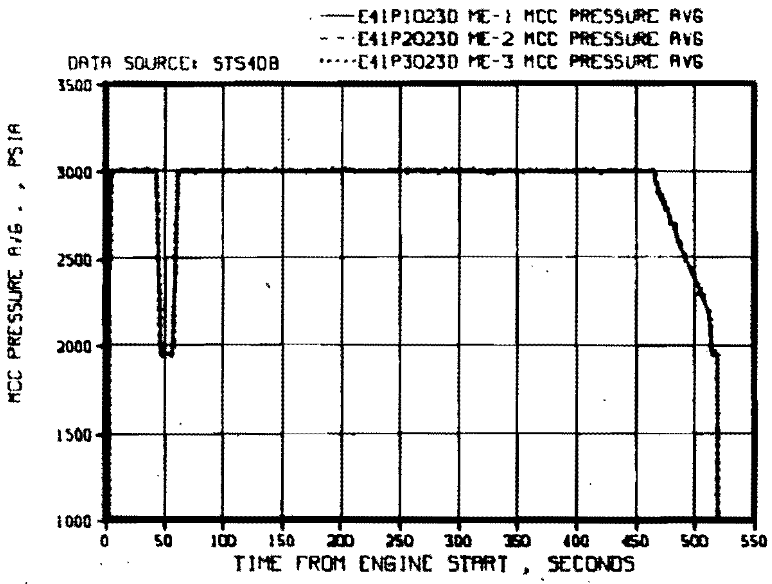


FIGURE 4.2.3-1 MAIN CHAMBER PRESSURE

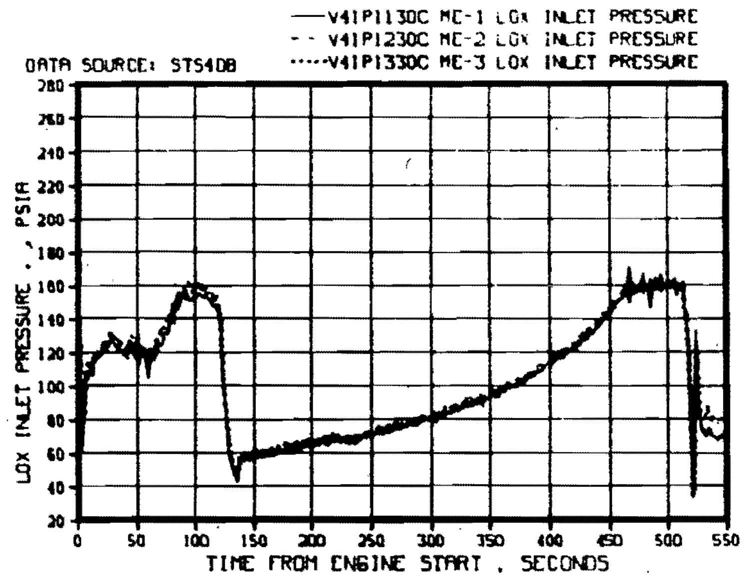


FIGURE 4.2.3-2 OXIDIZER INLET PRESSURE

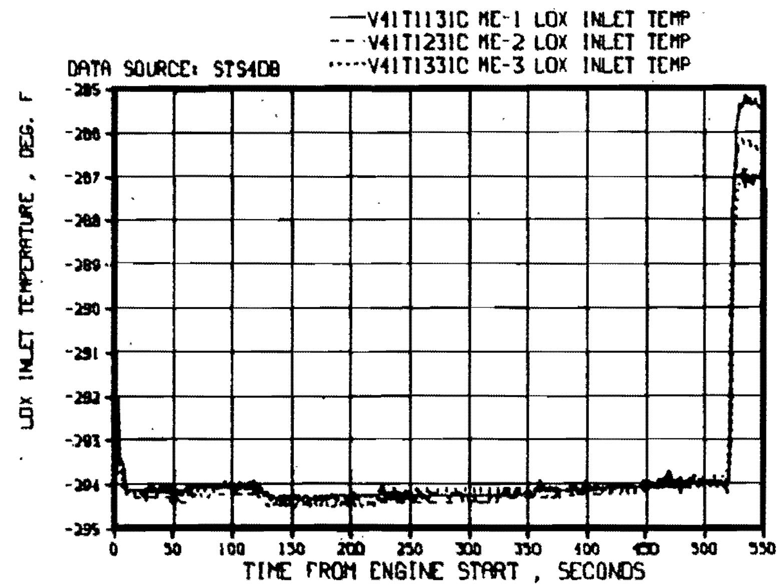


FIGURE 4.2.3-3 OXIDIZER INLET TEMPERATURE

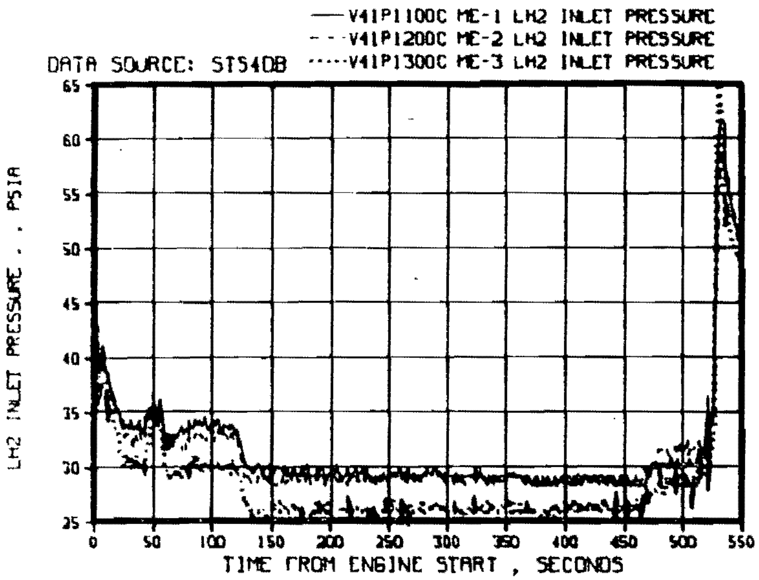


FIGURE 4.2.3-4 FUEL INLET PRESSURE

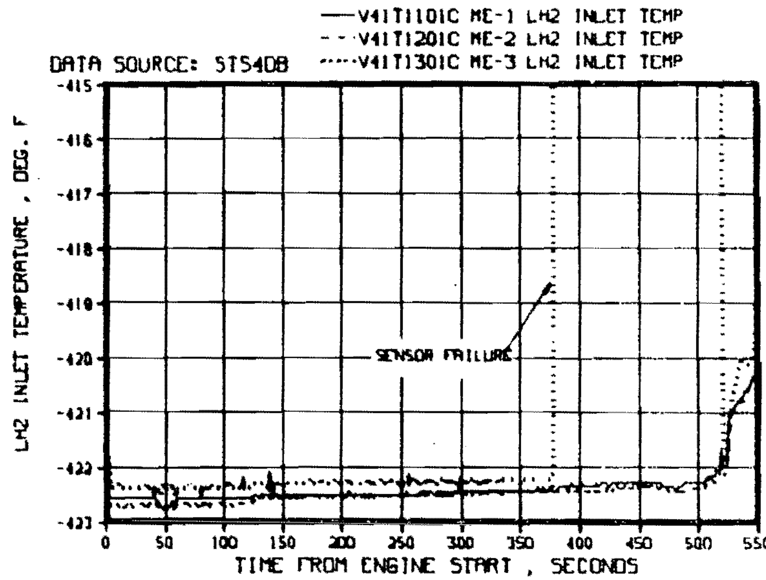


FIGURE 4.2.3-5 FUEL INLET TEMPERATURE

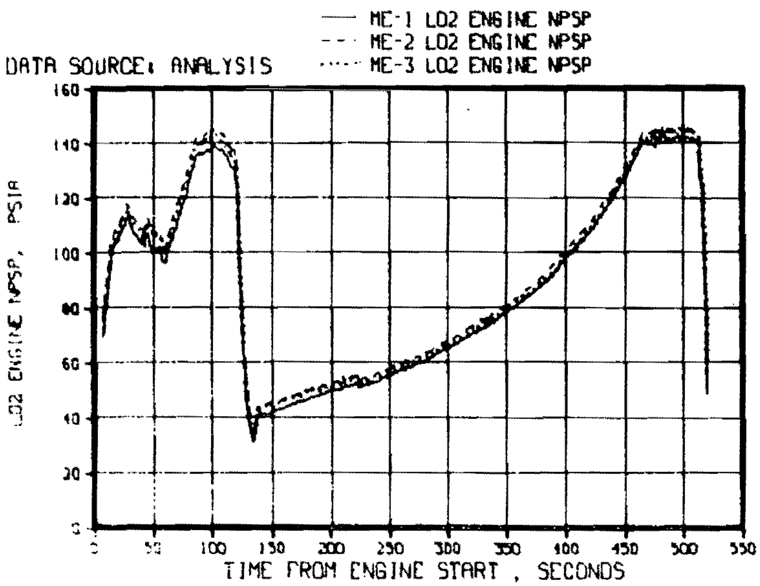


FIGURE 4.2.3-6 LO2 ENGINE NPSP

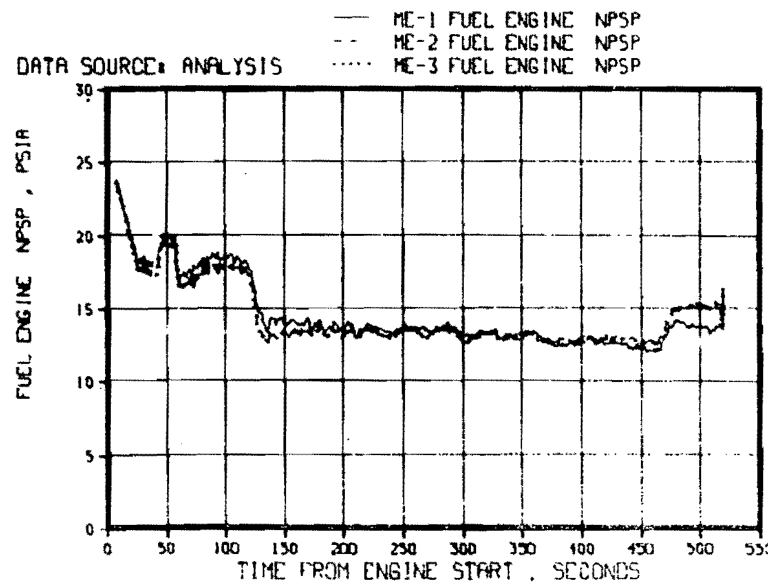


FIGURE 4.2.3-7 FUEL ENGINE NPSP

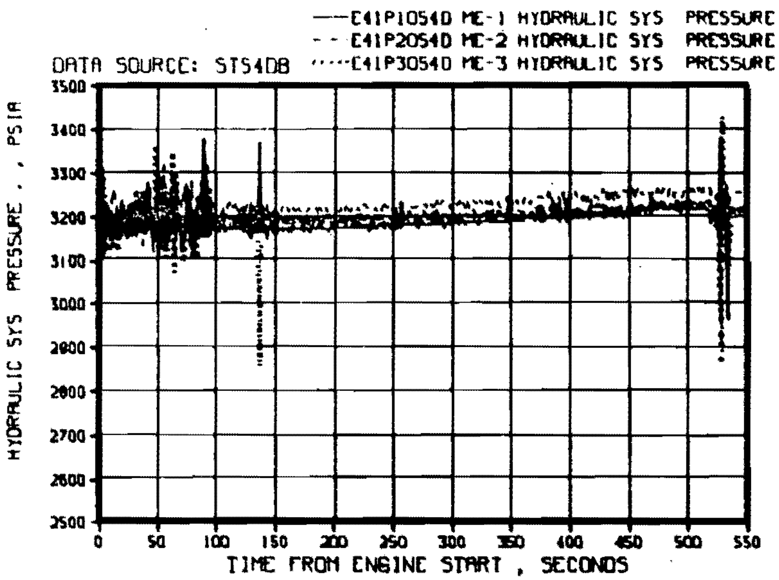


FIGURE 4.2.3-8 HYDRAULIC SYSTEM PRESSURE

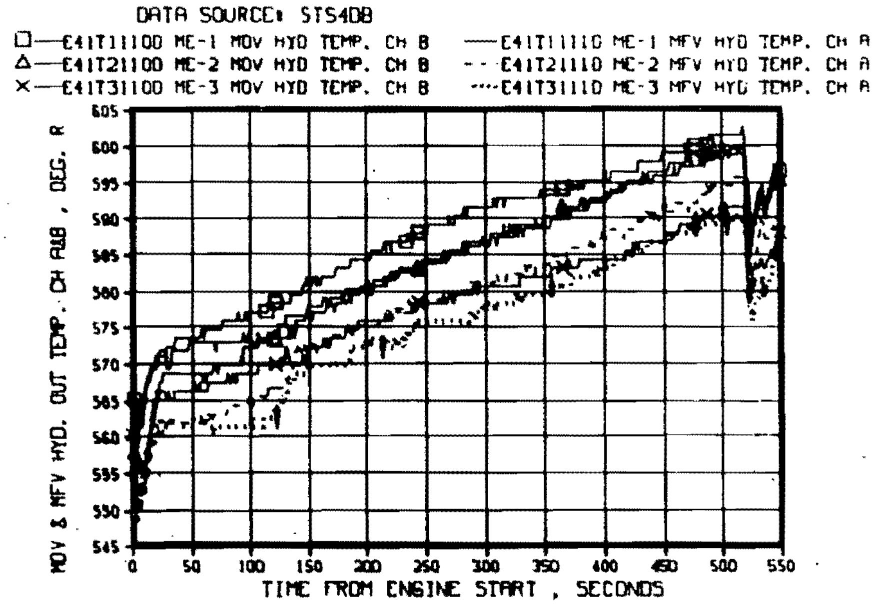


FIGURE 4.2.3-9 MOV & MFV HYDRAULIC OUTLET TEMP.

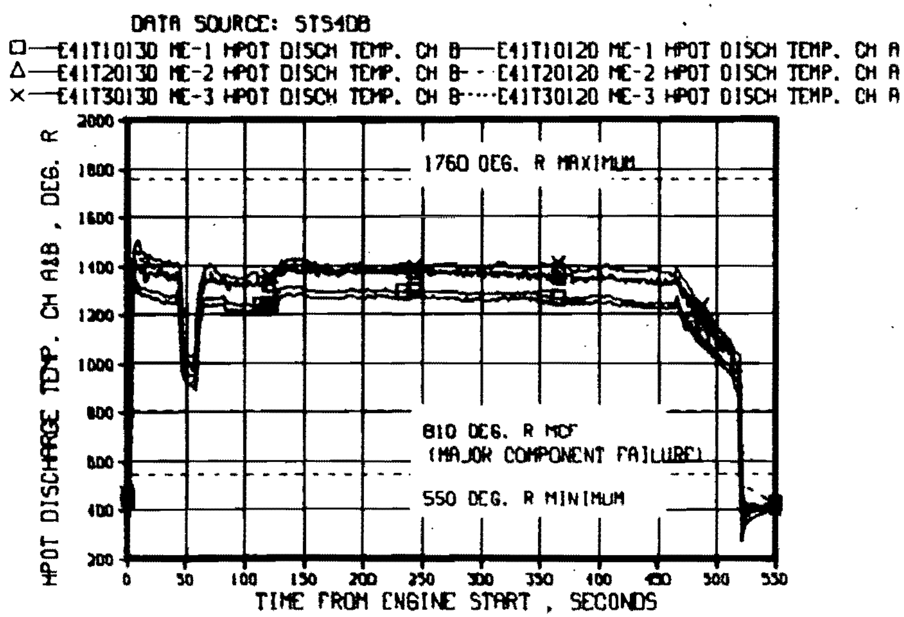


FIGURE 4.2.3-10 HPOT DISCHARGE TEMPERATURE

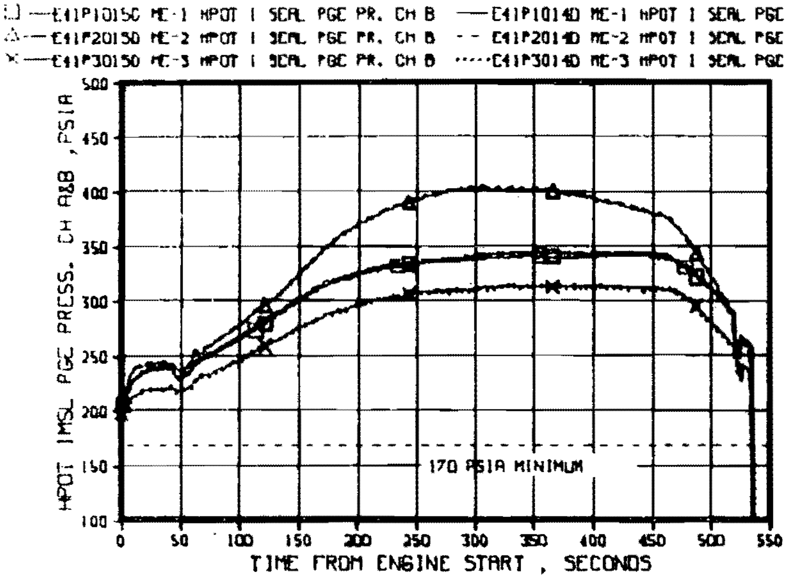


FIGURE 4.2.3-11 HPOT IMSL PURGE PRESSURE

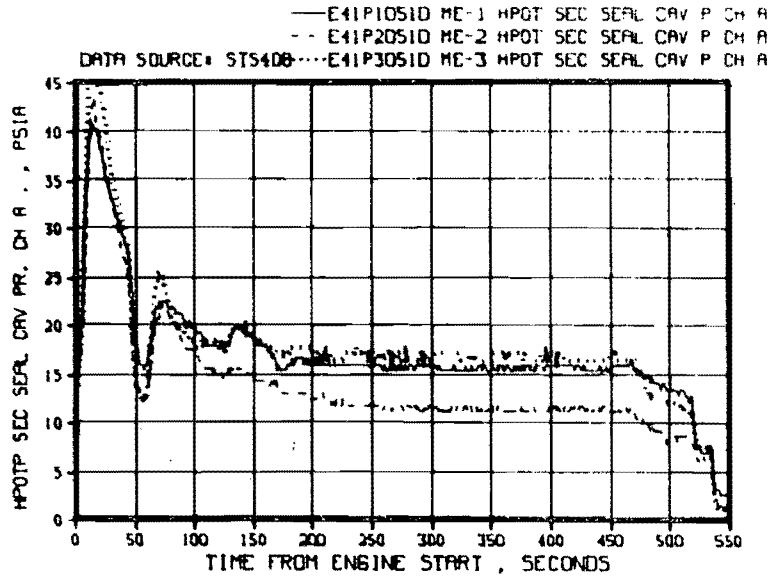


FIGURE 4.2.3-12 HPOTP TURBINE SECONDARY SEAL CAVITY PR.

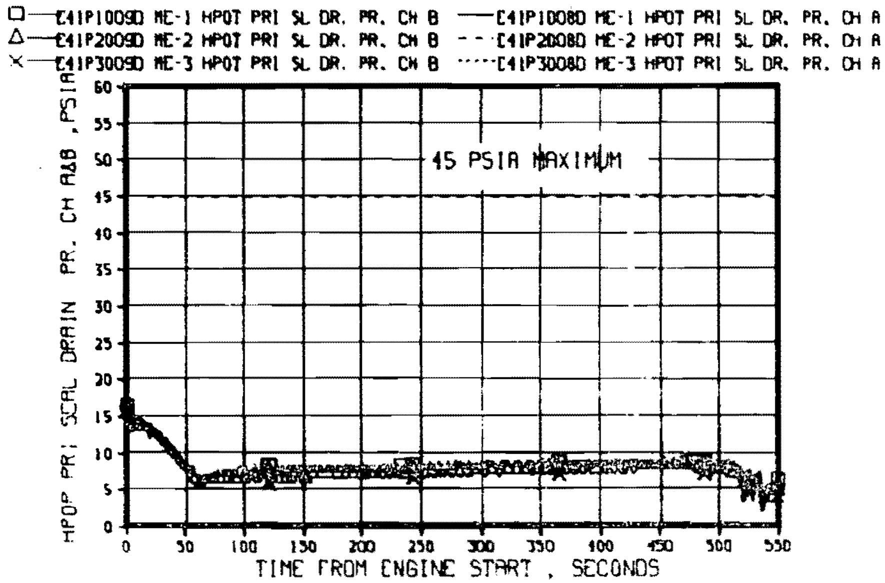


FIGURE 4.2.3-13 HPOT PRIMARY LOX SEAL DRAIN PRESSURE

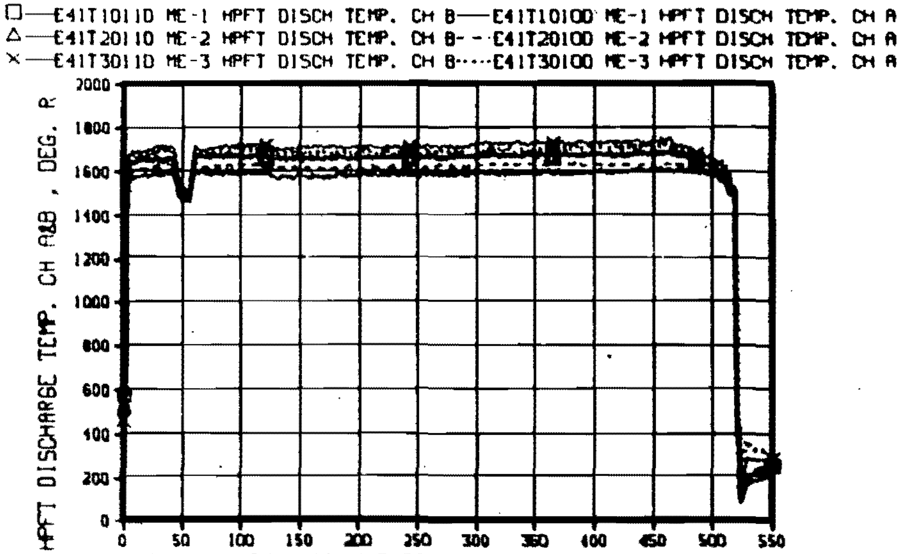


FIGURE 4.2.3-14 HPFT DISCHARGE TEMPERATURE

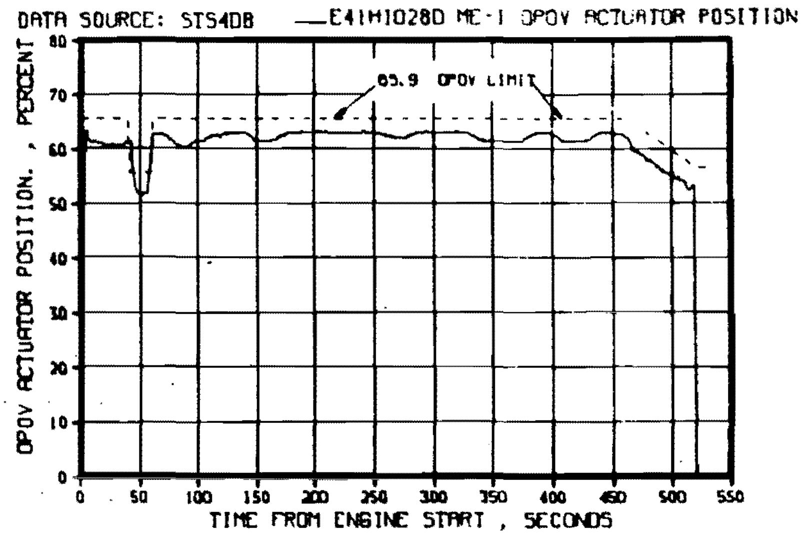


FIGURE 4.2.3-15 OPOV ACTUATION POSITION ME-1

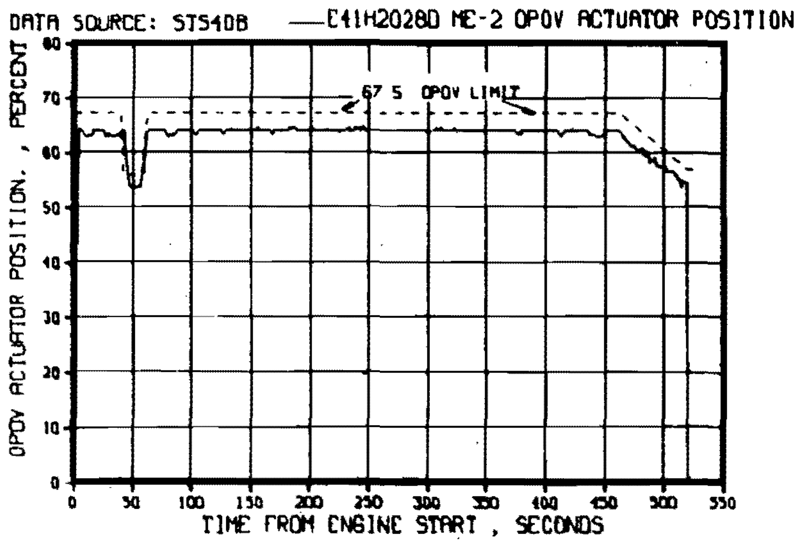


FIGURE 4.2.3-16 OPOV ACTUATION POSITION ME-2

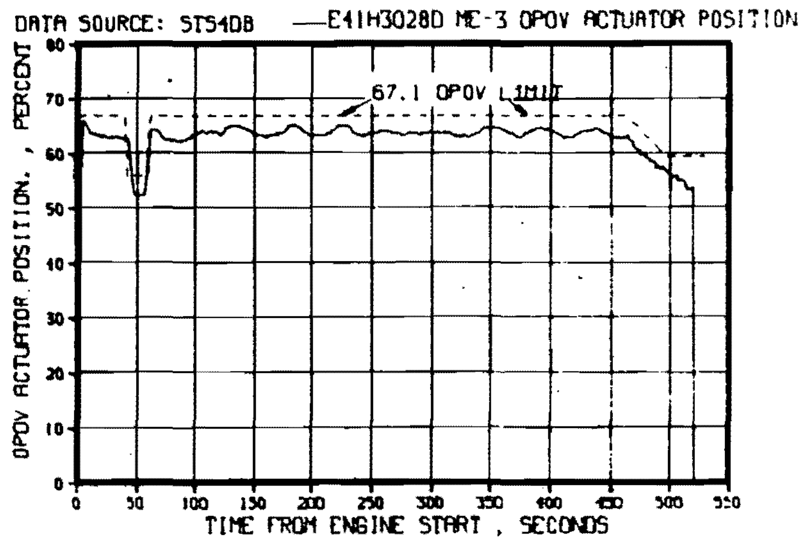


FIGURE 4.2.3-17 OPOV ACTUATION POSITION ME-3

Oxidizer tank pressurization performance was acceptable. Although actual repressurization temperatures on ME-1 and ME-3 were slightly above ICD limits, rated performance fell within limits for both the temperatures and pressures (Figures 4.2.3-18 and 19). Fuel tank pressurization performance was as expected. Orbiter measurements of GH2 pressurization system pressure and temperature are shown in Figures 4.2.3-20 and 21.

POGO system operation was normal (Figure 4.2.3-22). Engine gimbal operations were normal in response to Orbiter commands. The gimbal actuation positions during the flight are shown in Figures 4.2.3-23 through 25.

4.2.3.2 ENGINE PERFORMANCE - This section evaluates the performance of the SSME engines during the flight. The performance analysis used the Rocketdyne Flight Data Evaluation Program and was based upon Rocketdyne SSME tags issued prior to STS-4. A change in the performance model was made for the STS-4 analysis. The reasons for the change were 1) mission analysis indicated a change in thrust level during Stage 2 operation (150 to 450 seconds), and 2) reanalysis of the acceptance test data indicated a slight (less than .1%) thrust trending. Since this thrust trending influenced vehicle performance, it was decided to simulate the trending in the engine analysis.

Figure 4.2.3-26 shows the spread between channel A and channel B main engine chamber pressure during the flight. During the 100 to 450 second time slice, ME-2 and ME-3 had a 5 psia drift. The drift in ME-1 was negligible. For accuracy considerations, channel A was used to evaluate ME-2 and ME-3 performance. For consistency channel A was also used to evaluate the performance of ME-1. After thrust decay, zero shifts of the MCC channel A sensor were used to evaluate the flight data because of better agreement between main chamber pressure channel A and B data utilizing this method than others evaluated.

Table 4.2.3-3 gives the SSME performance during the standard 150-160 time slice. These values met SSME requirements and were consistent with the previously issued tag values. Table 4.2.3-4 gives a comparison of the actual flight values of the internal engine performance parameters compared with predictions. These predicted values were based upon SSME tag values corrected to actual inlet conditions occurring during the flight. All performance parameters were consistent with predicted. Figures 4.2.3-27 through 29 show the inlet mixture ratio, vacuum thrust and specific impulse of the three SSME engines during the flight. Figure 4.2.3-30 shows the vehicle inlet mixture ratio during the flight. The average mixture ratio during mainstage operation was 6.003. The overall mixture ratio including start and shutdown was 5.985. Figure 4.2.3-31 shows the vehicle thrust during Stage 2 operation. The vehicle vacuum thrust rise during the 200 to 450 second time frame was 10.2 lbs/sec. Sensor drift contributed 3.7 lbs/sec and thrust trending contributed the remaining 6.5 lbs/sec. Figure 4.2.3-32 shows the trending of thrust in the early portion of the flight. Thrust rise rates of minus 60 lbs/sec were determined. This effect is attributed to thrust trending. The vehicle specific impulse is shown in Figure 4.2.3-33. The average specific impulse during the flight Stage 2 based on engine reconstruction was 454.68 sec. The thrust, mixture ratio and specific impulse for various time slices are shown in Table 4.2.3-5. Propellant consumption during the flight is given in Table 4.2.3-6. Propellant consumption for STS-4 based on the engine reconstruction flow rates was 1,344,950 lbs of LO2 and 224,735 lbs of LH2.

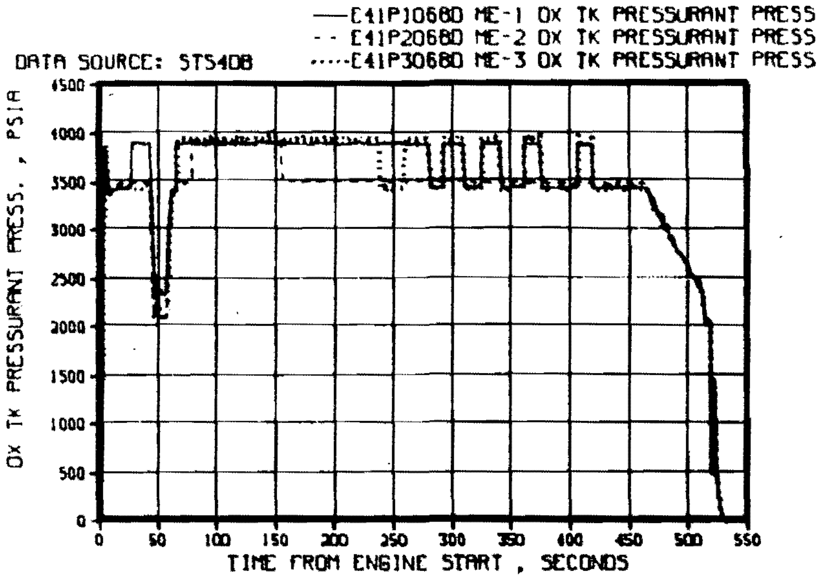


FIGURE 4.2.3-18 ENGINE GOX REPRESSURANT PRESSURE

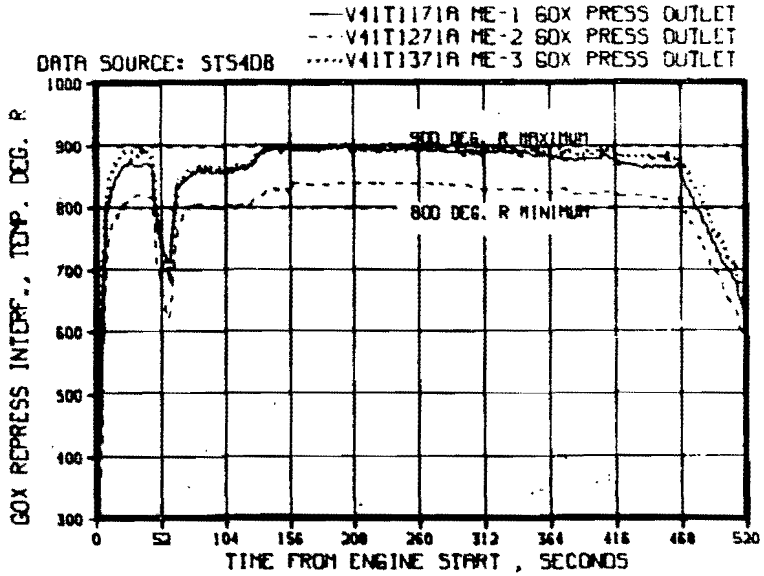


FIGURE 4.2.3-19 ME-1 GOX REPRESSURANT INTERFACE TEMP.

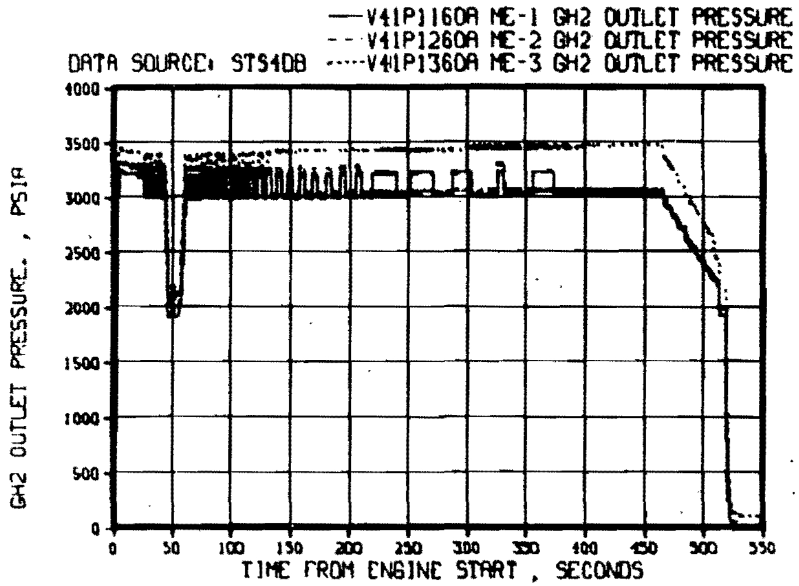


FIGURE 4.2.3-20 ENGINE GH2 REPRESSURANT PRESSURE

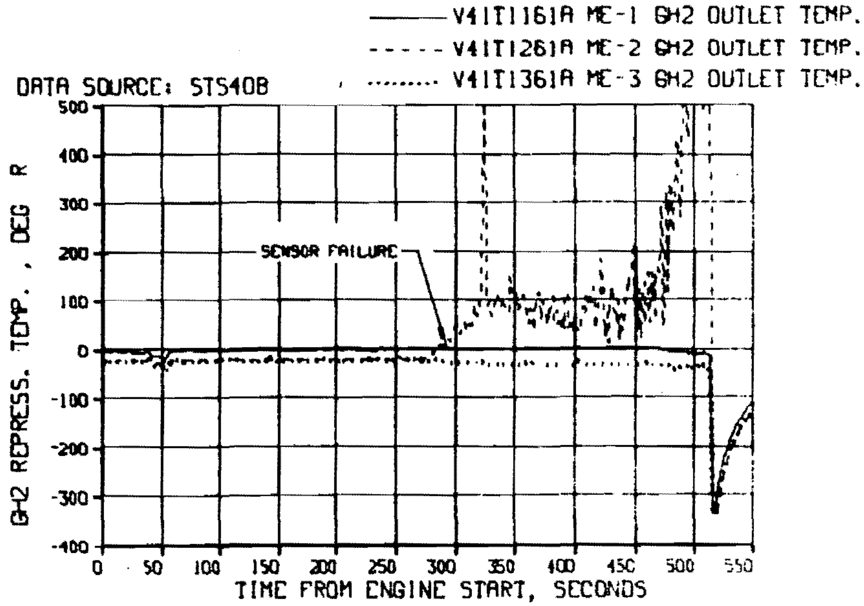


FIGURE 4.2.3-21 ENGINE GH2 REPRESSURANT TEMPERATURE

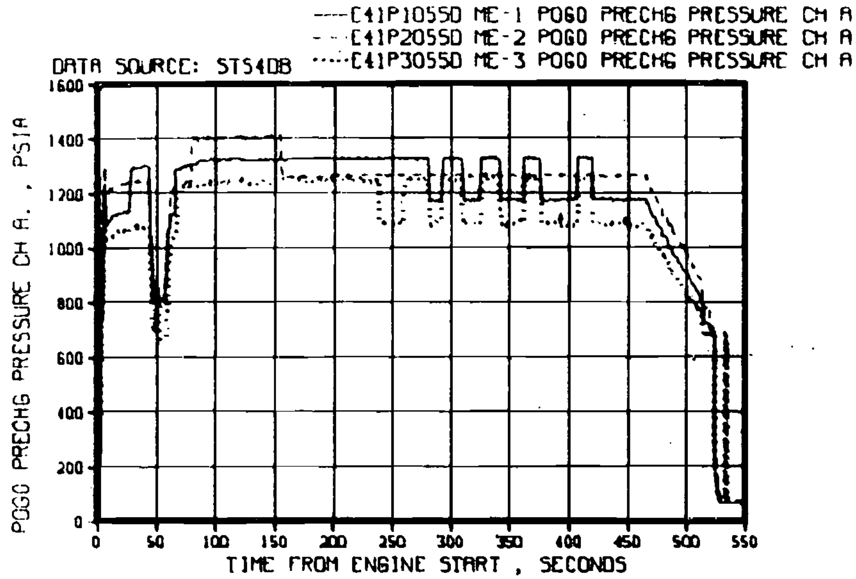


FIGURE 4.2.3-22 POGO PRECHARGE PRESSURE

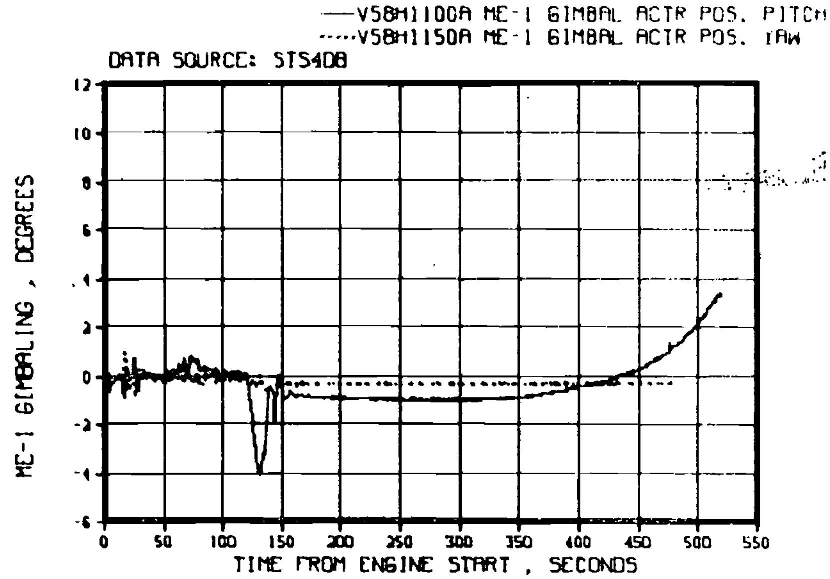


FIGURE 4.2.3-23 ME-1 GIMBAL ACTUATOR POSITION

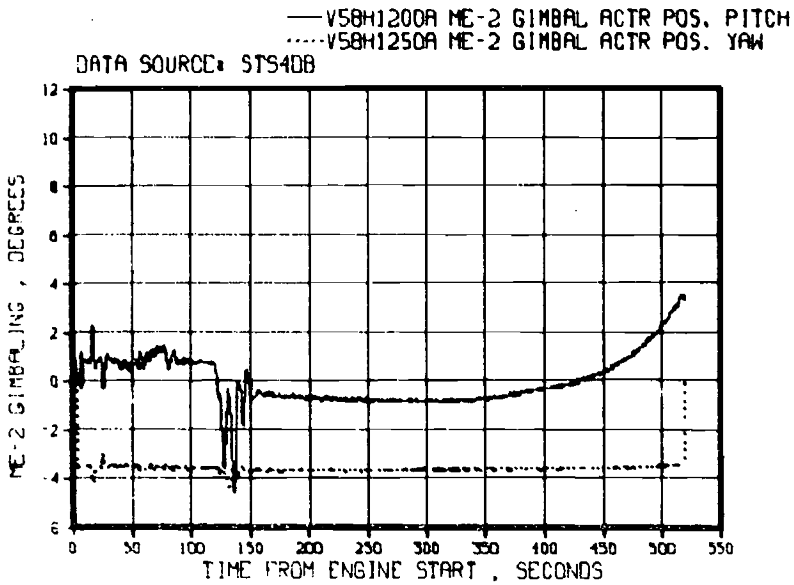


FIGURE 4.2.3-24 ME-2 GIMBAL ACTUATOR POSITION

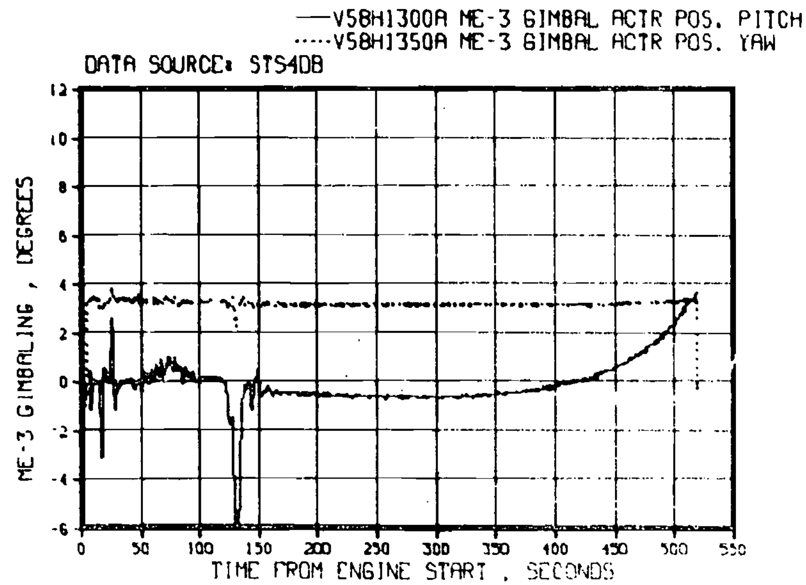


FIGURE 4.2.3-25 ME-3 GIMBAL ACTUATOR POSITION

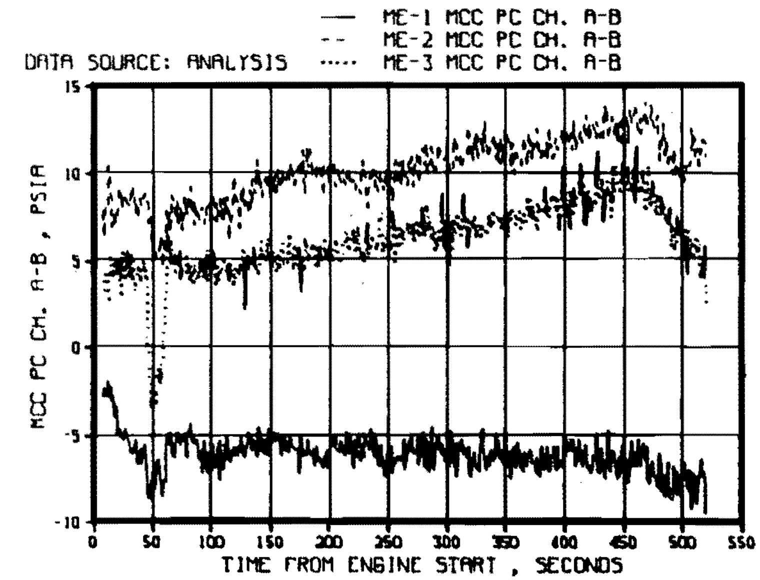


FIGURE 4.2.3-26 MCC CHAMBER PRESSURE CH. A-B

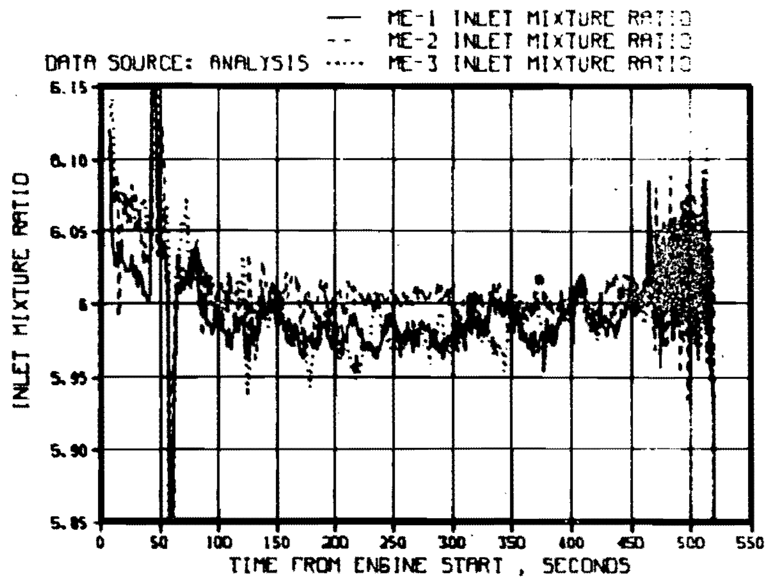


FIGURE 4.2.3-27 INLET MIXTURE RATIO

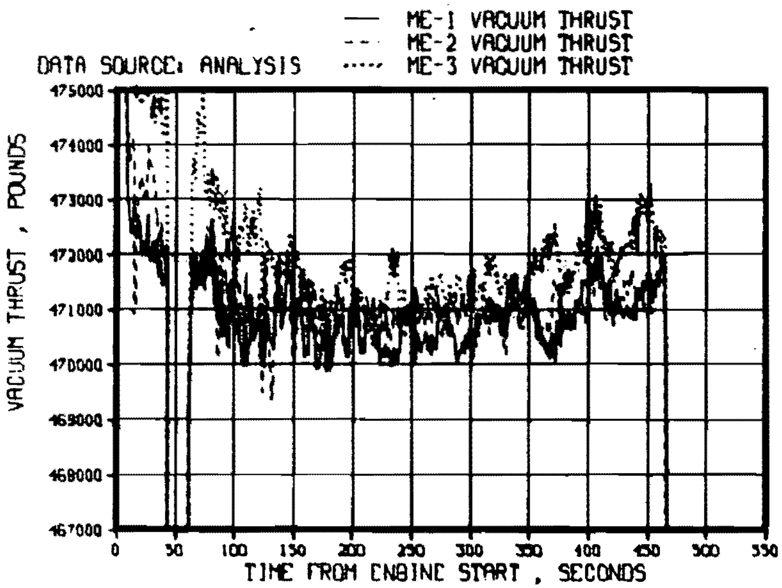


FIGURE 4.2.3-28 VACUUM THRUST

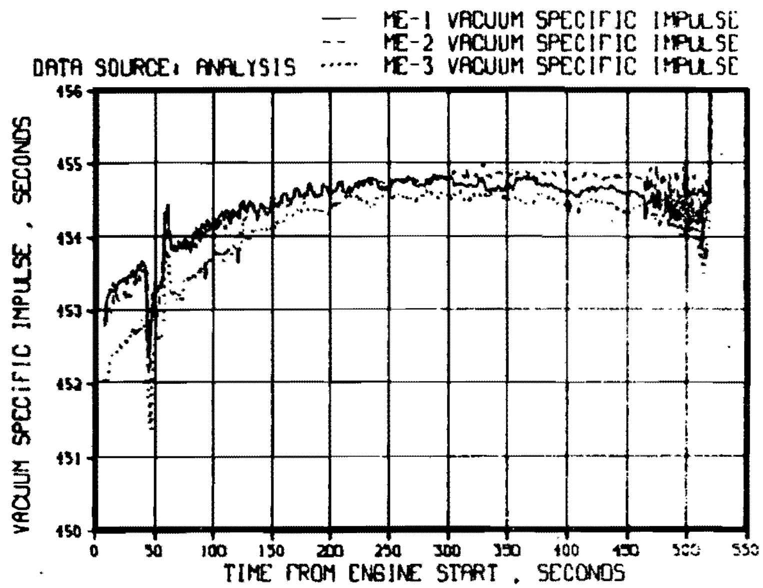


FIGURE 4.2.3-29 VACUUM SPECIFIC IMPULSE

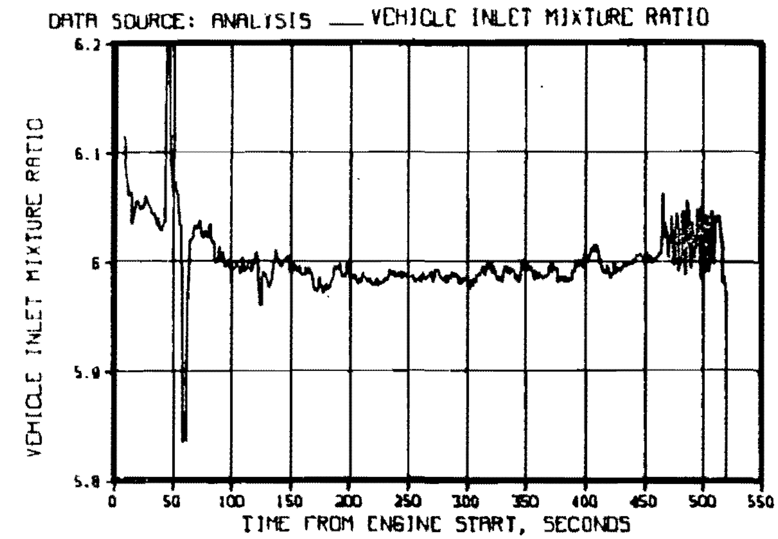


FIGURE 4.2.3-30 VEHICLE INLET MIXTURE RATIO

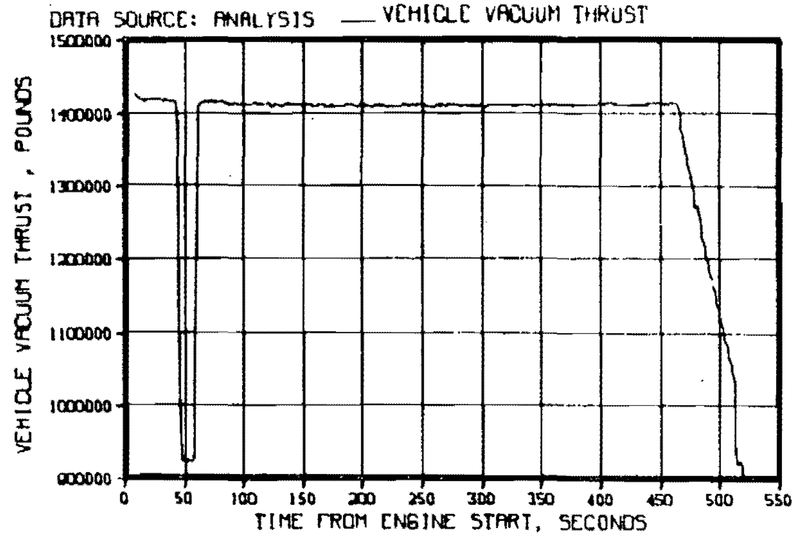


FIGURE 4.2.3-31 VEHICLE VACUUM THRUST

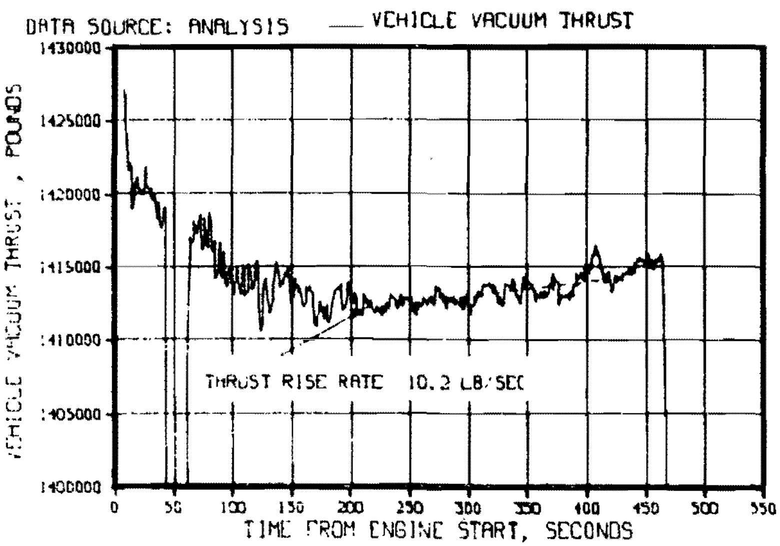


FIGURE 4.2.3-32 VEHICLE VACUUM THRUST (EXPANDED)

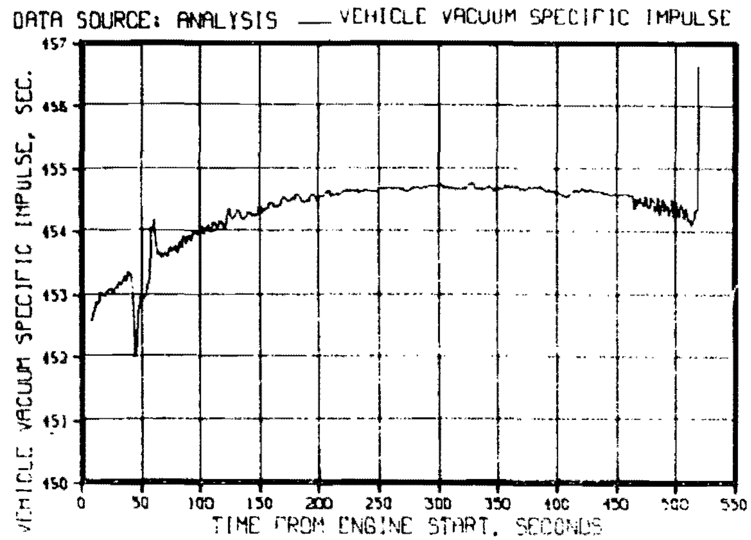


FIGURE 4.2.3-33 VEHICLE VACUUM SPECIFIC IMPULSE

TABLE 4.2.3-3 SSME STS-4 PERFORMANCE SUMMARY

STS4 10 SEC SHFTD CHAN A 08/03/82 12:45:34

FLIGHT MEASURED

TIME SLICE 150 TO 160 SECONDS

ENGINE PARAMETER	UNITS	ENGINE 1 2007	ENGINE 2 2006	ENGINE 3 2005
CHAMBER PRESSURE	PSIA	3009.4	3013.2	3011.4
INLET LO2 FLOWRATE	LB/SEC	889.30	890.48	891.41
INLET FUEL FLOWRATE	LB/SEC	148.50	148.30	148.78
MIXTURE RATIO	O/F	5.988	6.005	5.991
GO2 PRSRNT FLOWRATE	LB/SEC	1.123	1.755	1.141
GH2 PRSRNT FLOWRATE	LB/SEC	.679	.751	.454
VACUUM THRUST	LB	470847.	470960.	471719.
VACUUM ISP	SEC	454.48	454.48	454.19
STANDARD TANK PRESSURIZATION				
INLET LO2 FLOWRATE	LB/SEC	889.79	890.13	892.54
MIXTURE RATIO	O/F	5.992	6.002	5.999

TABLE 4.2.3-4 FLIGHT PERFORMANCE COMPARED TO PREDICTED

STS4 10 SEC SHFTD CHAN A 08/03/82 12:45:34

*PREDICTED

TIME SLICE 150 TO 160 SECONDS

ENGINE PARAMETER	ENGINE 1 2007		ENGINE 2 2006		ENGINE 3 2005	
	PRED	FLIGHT	PRED	FLIGHT	PRED	FLIGHT
HPOT SHAFT SPEED	27764.	27788.	28081.	27785.	27954.	28149.
HPFT SHAFT SPEED	34732.	34849.	34533.	34518.	34723.	34722.
HPOT DISCH PRESS	4043.	4009.	4033.	4045.	4072.	4080.
HPFT DISCH PRESS	6047.	6015.	6036.	5939.	6041.	5983.
OPB CHMBR PRESS	4940.	4940.	4988.	4988.	5010.	5010.
FPB CHMBR PRESS	4934.	4968.	4967.	4962.	4946.	4916.
LO2 FLOW- RATE	886.42	889.30	889.61	890.48	891.85	891.41
FUEL FLOW- RATE	148.03	148.50	148,19	148.30	148.79	148.78
VAC THRUST	469313.	470847.	470520.	470960.	471911.	471719.
OX TK PRSRNTFLOW	1.109	1.123	1.740	1.755	1.127	1.141
FL TK PRSRNTFLOW	.6772	.6787	.7503	.7514	.4528	.4539
OPOV CMD POS	.6386	.6188	.6494	.6423	.6332	.6393
FPOV CMD POS	.7638	.7755	.7649	.7570	.7733	.7809
MCC PRESS AVG	3009.4	3009.3	3013.2	3013.2	3011.4	3011.4
LPOT DISCH PRESS	314.70	320.36	288.41	324.64	309.49	325.68
LPFT DISCH PRESS	165.85	165.95	174.07	169.60	171.99	172.37
PBP DISCH PRESS	7366.	7405.	7534.	7382.	7420.	7345.
LOPT DISCH TEMP	171.3	171.3	171.2	171.2	171.4	171.4
HPOT DISCH TEMP	192.3	192.3	192.2	192.2	192.9	192.9
HPFT DISCH TEMP	94.21	94.21	94.60	94.60	93.30	93.30
PBP DISCH TEMP	205.5	205.9	206.8	205.1	207.7	207.6
LPFT DISCH TEMP	41.95	42.06	41.91	42.00	41.86	42.08
LPOT SHAFT SPEED	5040.	4624.	5023.	4997.	5084.	5117.
LPFT SHAFT SPEED	15020.	15015.	15311.	15225.	15357.	15330.
HPOTT DISCH TEMP	1294.	1292.	1454.	1382.	1390.	1403.
HPFTT DISCH TEMP	1576.	1623.	1594.	1639.	1548.	1701.
OPOV RESIST	213.9	280.0	186.1	203.7	229.5	211.9
FPOV RESIST	13.22	11.20	13.03	14.66	11.54	10.36
OX TK PRSRNTPRESS	4051.	3899.	3668.	3710.	4102.	3950.
FL TK PRSRNTPRESS	3423.	3099.	3420.	3136.	3572.	3439.
OX TK PRSRNTTEMP	902.7	896.6	856.3	832.6	895.8	897.2
FL TK PRSRNTTEMP	485.4	460.2	442.6	441.4	441.4	439.4
LPOT NSS	12867.	0.	12226.	0.	12425.	0.
LPFT NSS	18558.	18534.	19756.	19661.	19849.	19828.
HPOT NSS	12351.	12131.	13146.	12035.	12550.	12154.
HPFT NSS	6921.	7021.	6666.	6819.	6762.	6794.

* PREDICTED VALUES ARE BASED UPON ROCKETDYNE TAG VALUES CORRECTED TO INLET CONDITIONS OCCURRING DURING FLIGHT.

TABLE 4.2.3-5 VEHICLE PERFORMANCE SUMMARY FOR STS-4

STS4 1 SEC SHIFTED CHAN A 08/03/82 13:19:48

VEHICLE AVERAGES

VEHICLE AVERAGE DATA FOR		200.00	TO	449.50			
VEHICLE	THRUST-	1413451.	MR-	5.9916	ISP-	454.6843	
ENGINE 1	THRUST-	470852.	MR-	5.9854	ISP-	454.7147	
ENGINE 2	THRUST-	470967.	MR-	6.0051	ISP-	454.8171	
ENGINE 3	THRUST-	471632.	MR-	5.9843	ISP-	454.5216	
VEHICLE AVERAGE DATA FOR		200.00	TO	519.40			
VEHICLE	THRUST-	1371873.	MR-	5.9945	ISP-	454.6386	
ENGINE 1	THRUST-	456872.	MR-	5.9878	ISP-	454.6624	
ENGINE 2	THRUST-	457037.	MR-	6.0057	ISP-	454.7957	
ENGINE 3	THRUST-	457964.	MR-	5.9900	ISP-	454.4589	
VEHICLE AVERAGE DATA FOR		7.00	TO	519.90			
VEHICLE	THRUST-	1374820.	MR-	6.0019	ISP-	454.3526	
ENGINE 1	THRUST-	457769.	MR-	5.9926	ISP-	454.4413	
ENGINE 2	THRUST-	458007.	MR-	6.0121	ISP-	454.4983	
ENGINE 3	THRUST-	459044.	MR-	6.0008	ISP-	454.1196	

TABLE 4.2.3-6 PROPELLANT CONSUMPTION SUMMARY

STS4 1 SEC SHIFTED CHAN A 08/03/82 13:19:48

	START (2)(5)	STEADY STATE (3)	CUT OFF (4)(5)	TOTAL
ENGINE 1				
FUEL CONSUMED (LB)	576.0	74062.8	237.0	74875.8
LO2 CONSUMED (LB)	3109.0	443959.2	425.0	447493.2
IMPULSE (LB SEC)	1218000.0	230028952.1	282000.0	231528952.1
ENGINE 2				
FUEL CONSUMED (LB)	603.0	73943.9	231.0	74777.9
LO2 CONSUMED (LB)	3166.0	444644.2	414.0	448224.2
IMPULSE (LB SEC)	1267000.0	230122142.3	271000.0	231660142.3
ENGINE 3				
FUEL CONSUMED (LB)	613.0	74240.1	229.0	75082.1
LO2 CONSUMED (LB)	3329.0	445502.7	401.0	449232.7
IMPULSE (LB SEC)	1313000.0	230615957.5	260000.0	232188957.5
VEHICLE				
FUEL CONSUMED (LB)	1792.0	222246.8	697.0	224735.8
LO2 CONSUMED (LB)	9604.0	1334106.2	1240.0	1344950.2
IMPULSE (LB SEC)	3798000.0	690767051.9	813000.0	695378051.9
TOTAL LO2+FUEL (LB)	11396.0	1556352.9	1937.0	1569685.9
MIXTURE RATIO (O/F)	5.3594	6.0028	1.7791	5.9846

(1) DATA ARE PRESENTED AS CALCULATED AND MAY EXCEED THE SIGNIFICANT DIGITS.
(2) ENGINE START TO SRB IGNITION COMMAND
(3) SRB IGNITION COMMAND TO MECO
(4) MECO TO VALVE CLOSURE
(5) START AND SHUTDOWN VALVES NORMALIZED TO MAINSTAGE VALUES

4.2.4 SHUTDOWN PHASE - The shutdown transients were nominal. The shutdown occurred from MPL and all valves' closing positions and rates were normal. The thrust decay transients as shown in Figure 4.2.4-1, were similar to each other, agreed with predicted and fell within ICD limits. Flight results are compared to ICD requirements in Table 4.2.4-1. All ICD requirements were met.

Shutdown purge sequences and pressures were normal. No adverse turbine temperature transients were encountered (Figures 4.2.4-2 through 5). The LPFTP and HPFTP shaft speeds during the shutdown transient (Figure 4.2.4-6) were normal. The HPOTP pump speeds were determined from accelerometer data and were normal with no indication of overspeed of the pumps (Figure 4.2.4-7). The oxidizer NPSP during the shutdown was satisfactory (Figure 4.2.4-8).

TABLE 4.2.4-1 ENGINE SHUTDOWN FOR STS-4 COMPARED TO ICD REQUIREMENTS

PARAMETER	REQUIREMENTS	ME-1	ME-2	ME-3
POWER LEVEL AT SHUTDOWN (1)	NONE	65	65	65
TIME OF SHUTDOWN COMMAND (SEC) (1)	NONE	519.03	519.15	519.31
ENGINE SHUTDOWN TIME (SEC) (ECO to 1% PC) (2)	6.5	5.88	5.68	5.52
ENGINE SHUTDOWN RATE				
TOTAL (LBS/.01 SEC)	7,000 (MAX)	- 4,767	- 5,040	- 5,521
ABOVE 185,000 LBS THRUST (LBS/SEC)	-500,000 (MAX)	-372,512	-392,165	-380,676
BELOW 185,000 LBS THRUST (LBS/SEC)	-560,000 (MAX)	-106,981	-124,659	-106,712
ENGINE SHUTDOWN IMPULSE (LBS/SEC)	342,738 (MAX)	291,000	280,000	267,000
ENGINE PROPELLANT CONSUMPTION (3)				
TOTAL (LBS)	400/840 (MIN/MAX)	604	589	565
OXIDIZER (LBS)	280/600 (MIN/MAX)	425	414	399
FUEL (LBS)	120/240 (MIN/MAX)	179	175	166
FLOW DECELERATION				
OXIDIZER (LBS/SEC-SEC)	1570 (MAX)	900	950	1160
FUEL (LBS/SEC-SEC)	375 (MAX)	145	140	120

(1) INITIAL MOVEMENT OF OPOV COMMAND POSITION — ENGINE 1 CUTOFF 82:178:15:08:32:510
(2) TO ZERO THRUST APPROXIMATELY 1% PC AS DEFINED IN ICD — ENGINE 2 CUTOFF 82:178:15:08:32:517
(3) FROM MPL TO CLOSE OF MOV AND MFV — ENGINE 3 CUTOFF 82:178:15:08:32:547

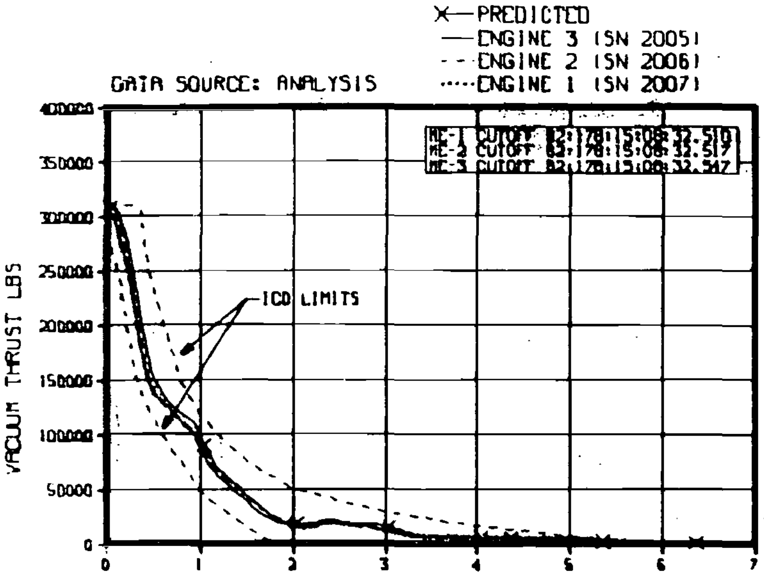


FIGURE 4.2.4-1 VACUUM THRUST DECAY DURING SHUTDOWN

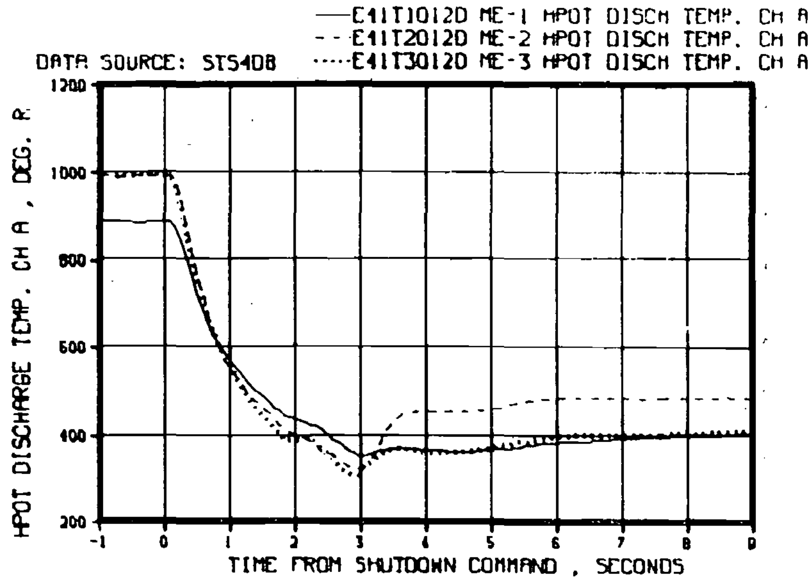


FIGURE 4.2.4-2 HPOT DISCHARGE TEMP. DURING SHUTDOWN

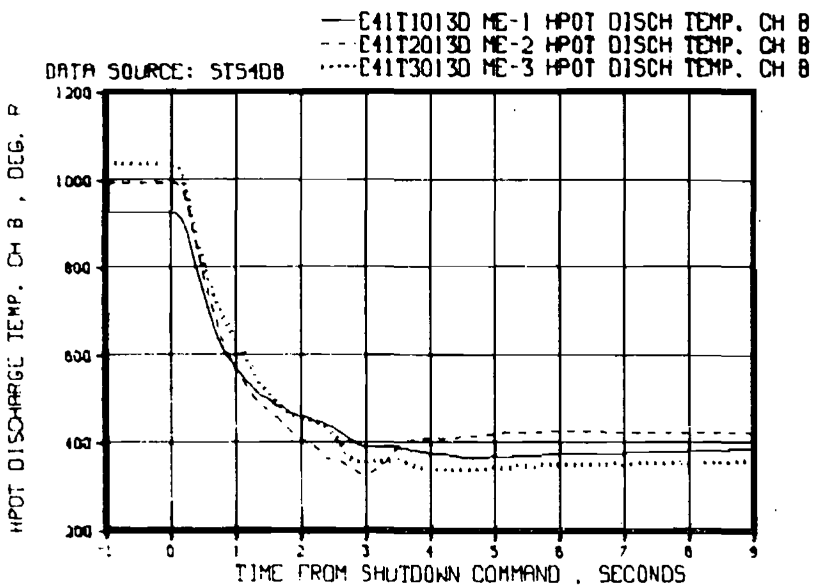


FIGURE 4.2.4-3 HPOT DISCHARGE TEMP. DURING SHUTDOWN

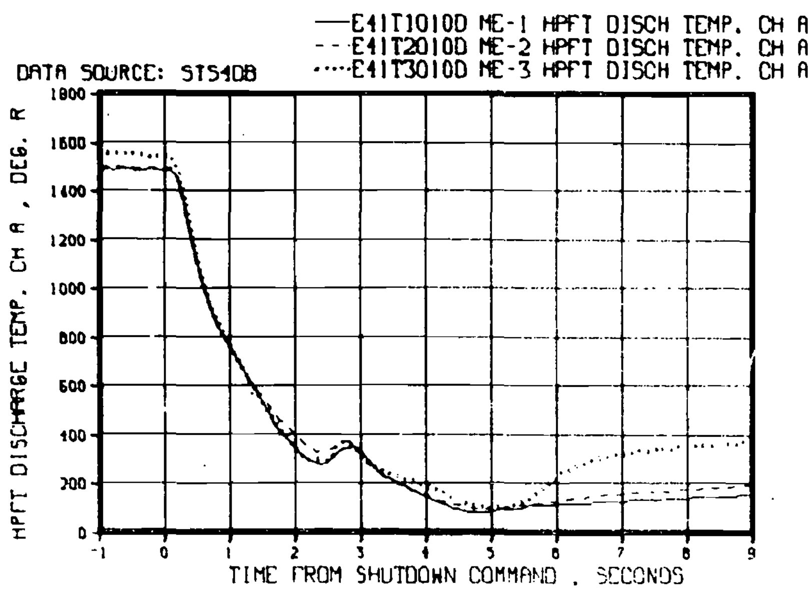


FIGURE 4.2.4-4 HPFT DISCHARGE TEMP. DURING SHUTDOWN

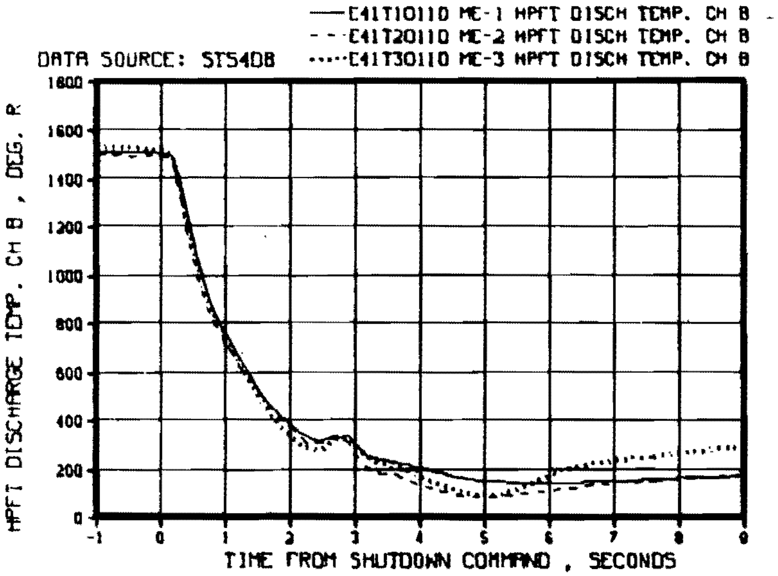


FIGURE 4.2.4-5 HPFT DISCHARGE TEMP. DURING SHUTDOWN

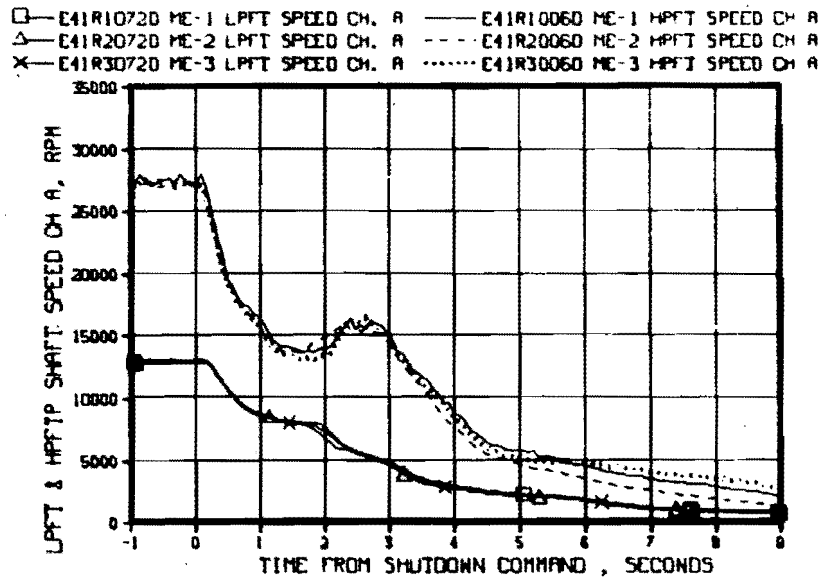


FIGURE 4.2.4-6 LPFT & HPFTP SHAFT SPEED DURING SHUTDOWN

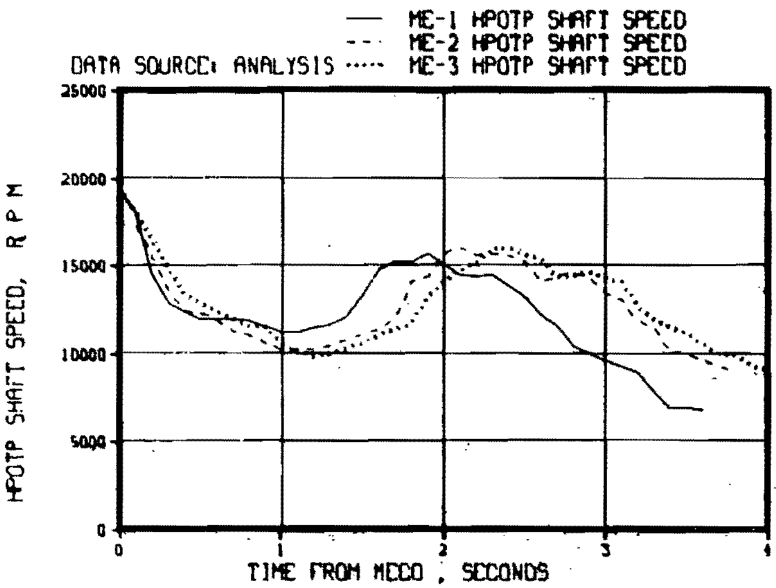


FIGURE 4.2.4-7 HPOTP SHAFT SPEED DURING SHUTDOWN

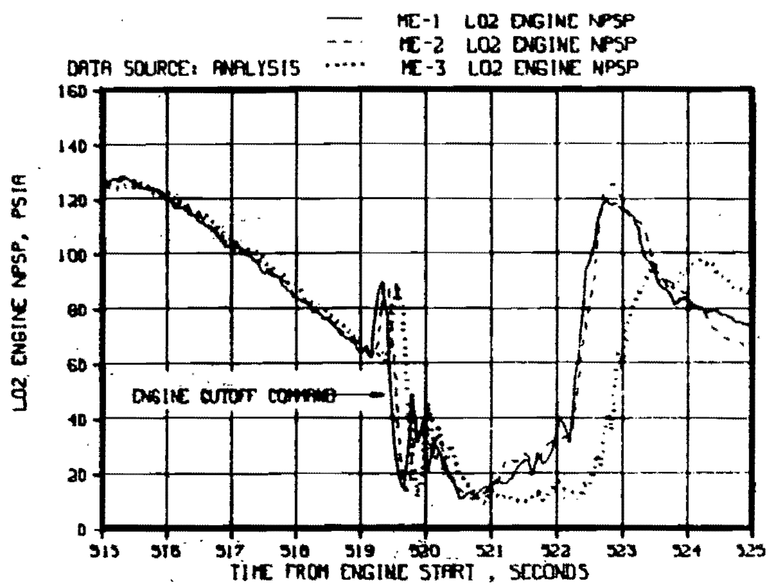


FIGURE 4.2.4-8 LO2 ENGINE NPSP DURING SHUTDOWN

4.2.5 POST SHUTDOWN - The propellant dump consisted of dumping the LO2 through the MCC injector by opening the MOV. LH2 was dumped by opening the LH2 prevalve, bleed valves, and LH2 topping valves allowing the LH2 to dump out the fill and drain port. This operation was performed satisfactorily. A more detailed discussion of the propellant dump and vacuum inerting is given in Section 5.4.6.

4.2.6 POSTFLIGHT EVALUATION - The following tables describe the post hardware report and software changes, post instrumentation report, ICD and LCC changes for STS-5 (Tables 4.2.6-1 through 4.2.6-5).

TABLE 4.2.6-1 POST HARDWARE REPORT

ITEMS	ACTION
SCHEDULED CHANGES	
ME-1, HPOTP FIRST STAGE BLADE INSPECTION U/N 0007R1	INSPECT PER ECP 473 3000 SEC LIMITATION. 1
UNSCHEDULED CHANGES	
ME-1, ONE COLDWALL PINHOLE LEAK	BRAZE REPAIR PINHOLE, FISHMOUTH INSERT TYPE.
ME-1, TWO CLASS II COLDWALL LEAKS AT AFT MANIFOLD	REPAIR COLDWALL LEAKS
ME-1, ONE CLASS III HOTWALL LEAK AT JOINT G-15	G-15 LEAK REPAIRED WITH LOCTITE AT DRYDEN
ME-1, MINOR TPS DAMAGE	STANDARD REPAIR
ME-1, HPOTP INDICATED SLIGHT INCREASING VIBRATION LEVELS DURING GREEN RUN U/N 0007R2	REPLACED WITH U/N 9009R3 S/N 4879729
ME-2, MCC CHANNEL B IGNITER FAILED POST IGNITER CHECKOUT TEST	REPLACED WITH LIKE PART
ME-2, TPS DAMAGE	STANDARD REPAIR
ME-2 TWO CLASS II HOT WALL NOZZLES LEAKS, ONE AT AFT MANIFOLD, ONE AT 6 FT. FROM AFT MANIFOLD. ONE CLASS III HOTWALL LEAK AT G-15	LOCTITE REPAIR AT AFT MANIFOLD AND G-15
ME-3, HPFTP HIGH TORQUE DURING POST TEST INSPECTION, METAL MISSING FROM 2ND STAGE IMPELLER	REPLACED WITH U/N 9006R2 S/N 4382640 2
ME-3, CONTAMINANT IN OPB ELEMENT A-11	REMOVE CONTAMINANT - DETERMINED TO BE TITANIUM ALLOY (FROM THE HPFTP 2ND STAGE IMPELLER)
ME-3, CONTAMINANTS FOUND IN MFV DURING SPECIAL POST TEST INSEPCTION	REPLACE MFV AND ACTUATOR WITH MFV S/N 4912559 AND MFVA S/N 036
ME-3, ONE CLASS II HOT WALL LEAK AT NOZZLE AFT MANIFOLD	LOCTITE REPAIR
ME-3, ONE CLASS III COLDWALL NOZZLE LEAK AT H/B 9	FISHMOUTH INSERT TYPE. REPAIR COLDWALL LEAK
ME-3, TPS DAMAGE	STANDARD REPAIR
ME-3, FOUND Q-TIP STICK IN FPB ASI FUEL SUPPLY LINE	REMOVED

1 BLADES REPLACED BY ROCKETDYNE TO UPGRADE HPOTP - INSPECTION SCHEDULED, NOT CHANGE
2 SEE FIPR NO. MSFC-2 (SECTION 4.1.3)

TABLE 4.2.6-2 SOFTWARE CHANGES FOR STS-5

ITEMS	EFFECT	ACTION
REMOVAL ANTI-GEYSER LINE	INCREASE OXIDIZER INLET TEMPERATURE	INCREASE ENGINE READY LIMIT FOR PIP DISCHARGE TEMPERATURE FROM 178 DEG R TO 186.5 DEG R
HIGH PRESSURE FUEL TURBINE DISCHARGE TEMPERATURE REDLINE	PROVIDE FAST ENGINE PROTECTION REPONSE AGAINST FAILURE DUE TO HIGH HPFT DIS-CHARGE TEMPERATURE	REDUCE ONE TIME CHECK AT 4.5 SEC FROM 1960 DEG R TO TBD DEG R. INCORPORATE MAIN-STAGE REDLINE CH A SET FOR TBD DEG R CH B SET FOR TBD DEG R SAME VOTING LOGIC AS HPOT DISCHARGE TEMPERATURE REDLINE
ELIMINATION OF DUAL BLEED VALVE CYCLE PRIOR TO START	DECREASE OXIDIZER INLET TEMPERATURE	CHANGE POGO PRECHARGE PRESTART PURGE DURATION FROM 220 TO 440 MSECS
ME-1 START BUILD-UP SLOW	REDUCE PC IGNITION. CONFIRM MARGIN	INCREASE OPOV OPEN LOOP COMMAND FROM 47% TO 48%
ME-2 START BUILD-UP SLOW	REDUCE PC IGNITION. CONFIRM MARGIN	INCREASE OPOV OPEN LOOP COMMAND FROM 48% TO 49%
ME-3 OPOV WITHIN 1% OF THRUST LIMIT POSITION (REQUIRED MARGIN 2%)	MCF PRIOR TO SRB IGNITION	INCREASE OPOV THRUST POSITION LIMIT BY 1% TO 68.1% IN SOFTWARE

TABLE 4.2.6-3 POST INSTRUMENTATION REPORT

ITEMS	ACTION
ME-1 POGO DFI TRANSDUCER-HPOTP INLET PRESSURE FAILED, DATA SATURATION	REPLACED PER RAR KLO-209
ME-1 FASCOS ACCELEROMETER PBP RADIAL 45-1, FAILED AT 230 SEC	REPLACED ACCEL & CABLE
ME-2 FUEL PREBURNER PC TRANSDUCER DATA FAILURE AT 506 SEC	FAILED TRANSDUCER, REPLACED WITH S/N 400
ME-2 FASCOS ACCELEROMETER HPFTP RADIAL 90, FAILED AT 460 SEC	REPLACED ACCEL & CABLE
ME-2 POGO DFI TRANSDUCER - HPFTP INLET PRESSURE - SATURATED OUTPUT	NO ACTION REQUIRED, WAIVED
ME-3 FASCOS ACCELEROMETER PBP RADIAL 135-3, EXTREME NOISE	REPLACED ACCEL & CABLE

TABLE 4.2.6-4 ICD CHANGES FOR STS-5

ITEMS	EFFECT	ACTION
CHANGE TO PRESTART PROPELLANT CONDITIONS FOR ANTI-GEYSER LINE DELETION	INCREASE LO2 INLET TEMPERATURES	APPROVED - IRN0244 PRCBD S03655HR3 9-7-81
CHANGE TO SSME BLEED VALVE OPERATION DURING PSN-4	ELIMINATE ADDITIONAL BLEED VALVE CYCLE	APPROVED - IRN0259 PRCBD - S021361 7-26-82
REVISES MAINSTAGE FUEL NPSP REQUIREMENTS	DECREASES REQUIRED NPSP AT RPL AND FPL	APPROVED - IRN 0237 PRCBD - S05755A 5-12-81

TABLE 4.2.6-5 LCC CHANGES FOR STS-5

REVISION	LCC PAGE NO.
PREBURNER PUMP DISCHARGE TEMPERATURE MAXIMUM - 186.5 DEG R (WAS 178 DEG R)	6.2.2-5
HPFT DISCHARGE TEMPERATURE ONE TIME CHECK MAXIMUM - 1860 DEG R (WAS 1960 DEG R)	6.2.2-13
INCORPORATION OF HPFT DISCHARGE TEMPERATURE REDLINE DURING MAINSTAGE. SET FOR TBD DEG R CHANNEL A AND TBD DEG R CHANNEL B MAXIMUM	6.2.2-14

4.3.0 INSTRUMENTATION – Each SSME has 43 flight transducers or 129 transducers for the flight engine set. Many of these transducers are equipped with dual recording capability resulting in 66 measurements per engine for a total of 198 measurements for the flight set. The utilization of each type transducer per engine is depicted in Table 4.3.0-1.

TABLE 4.3.0-1 TRANSDUCER ALLOCATION

TYPE	QUANTITY	MEASUREMENTS
PRESSURE	20	30
TEMPERATURE	9	13
SPEED/FLOW	5	8
POSITION	9	15
TOTAL	43	66

Operation of the SSME flight instrumentation was excellent except for the failure of the fuel preburner chamber pressure sensor on ME-2 (E41P2031D,B). This instrument will be replaced prior to STS-5. This is a maintenance only parameter and has no effect on engine performance.

4.3.1 SSME THERMAL DFI – In addition to the operational flight instrumentation, there were a total of 86 thermal DFI and 12 leak detection transducers installed on the SSMEs for STS-4 flight. Of the 86 thermal DFI transducers, 25 are installed on ME-1, 57 on ME-2, and four on ME-3. There are also four prelaunch leak detection measurements installed on each of the SSME engines. A breakdown of the transducer type per engine is shown in Table 4.3.1-1.

TABLE 4.3.1-1 THERMAL DFI TRANSDUCERS

TRANSDUCERS	ME-1	ME-2	ME-3
ASCENT			
CALORIMETER	7	7	2
CALORIMETER SURFACE TEMPERATURE	7	7	2
RADIOMETERS	3	2	-
SKIN TEMPERATURES	6	19	-
SURFACE PRESSURES	2	-	-
REENTRY			
CALORIMETER	-	11	-
CALORIMETER SURFACE TEMPERATURE	-	11	-
TOTALS	25	57	4

Progressive flight to flight deterioration of data was experienced as expected. As specific examples, E41T9212A and E41T9149A exhibit increasing deviations from expected nominal behavior explained by increased detachment from the mounting surface. Scaling factors for all parameters appear valid. Measurements yielding the largest flight to flight differences are those that were at one time functioning properly and then were lost, invalidating a comparison of magnitudes. No flight to flight deviations of significance were noted on any properly functioning DFI parameters.

4.3.2 <u>FASCOS</u> – Each SSME has six accelerometer measurements to monitor high pressure turbopump vibration data. Four of these measurements are mounted on the high pressure oxidizer turbopump and two on the high pressure fuel turbopump. Of the 18 measurements reviewed (total for the flight engine set), the FASCOS accelerometers provided generally good quality data. The channels that were questionable are shown in Table 4.3.2-1.

Of the seven listed questionable measurements, only two (ME-1 PBP 45-1 and ME-2 HPFP 90) exceeded the (inactive) 12 GRMS redline value. Had the redline value been active for STS-4, no SSME shutdown would have resulted from these instrumentation errors. The action to remove and replace these accelerometers and cables should preclude similar behavior during STS-5.

TABLE 4.3.2-1 QUESTIONABLE FASCOS INSTRUMENTATION

FASCOS CHANNEL	DESCRIPTION	ACTION
ME-1 PBP 45-1	FAILED +230 SEC	REMOVE & REPLACE ACCEL. & CABLE
ME-2 HPFP 90	FAILED +460 SEC	REMOVE & REPLACE ACCEL. & CABLE
ME-3 PBP 45-1	VERY NOISY	REPLACE COAXIAL CABLE
ME-3 PBP 135-3	EXTREME NOISE	REMOVE & REPLACE ACCEL. & CABLE
ME-3 PBP 135-1	NOISY	VISUAL INSPECTION OF ACCEL INSTALLATION
ME-3 PBP 180-1	SPIKES	VISUAL INSPECTION OF ACCEL INSTALLATION
ME-3 HPFP 90	SPIKES	VISUAL INSPECTION OF ACCEL INSTALLATION

Postflight inspection of the ME-2 HPFTP radial 90 accelerometer showed that the cable coax was torn. ME-3 PBP 45-1 radial accelerometer revealed a bad cable and had been replaced for STS-5. The remaining accelerometers which were inspected revealed no anomalies and no further action was taken.

4.3.3 <u>POGO DFI</u> – There were 19 POGO DFI measurements installed on the SSME flight set for STS-4. The measurement locations and quality of data output are presented in Table 4.3.3-1.

TABLE 4.3.3-1 POGO DFI MEASUREMENTS

MEASUREMENT	ME-1	ME-2	ME-3
MCC PC	1	1	1
HPFTP INLET PR.	1	2	1
HPOTP INLET PR.	2	1	1
POGO ACCUMULATOR PR.	1	1	1
HPOTP X AXIS ACCEL.	1	1	1
HPOTP Y AXIS ACCEL.	1	1	4
HPOTP Z AXIS ACCEL.	1	1	4

CODE: 1) ACCEPTABLE
2) NOT ACCEPTABLE
3) QUESTIONABLE
4) NOT INSTALLED

The descriptions of the discrepancies are as follows:

(1) HPOTP Inlet Pressure (E41P9197A) showed saturation and drift at start.
(2) HPFTP Inlet Pressure (E41P9298A) showed no data.

4.4.0 ENGINE CONTROLLER PERFORMANCE - This subsection provides a performance summary for the three engine controllers in the evaluation areas of software, response, accuracy, stability, and hardware.

4.4.1 SSME CONTROLLER SOFTWARE PERFORMANCE - The controller software performance is considered satisfactory. Its performance can best be determined by examination of any reported failure identifications (FIDS). No software problem FIDS nor system hard failure FIDS were reported.

Table 4.4.1-1 summarizes the software configuration of the STS-4 controllers and notes their results. All software changes made prior to STS-4 are shown in Table 4.4.1-2.

TABLE 4.4.1-1 CONTROLLER HARDWARE AND SOFTWARE SUMMARY

SOFTWARE CONFIGURATION	HARDWARE CONFIGURATION	
FLIGHT VERSION 20	HARDWARE	BURN (SEC)
	ME-1(2007/F6)	519.03
SOFTWARE CHANGES AND PROBLEMS	ME-2(2006/F4)	519.15
NO SOFTWARE PROBLEMS IDENTIFIED	ME-3(2005/P7)	519.31
SOFTWARE CHANGES MADE PRIOR TO STS-4 ARE GIVEN IN TABLE 4.4.1-2		
FLIGHT FAILURE ID'S		
NONE		

TABLE 4.4.1-2 SSME SOFTWARE CHANGES FOR STS-4

PROBLEMS	EFFECT	ACTION
ME-3 START BUILD UP SLOW.	REDUCE PC IGNITION CONFIRM MARGIN.	INCREASE ME-3 OPOV OPEN LOOP COMMAND FROM 47 TO 48%.
POGO PRECHARGE PRESSURE EXCEEDS UPPER LIMIT	FID REPORTED DUE TO TOO LOW UPPER LIMIT BEING SET.	UPPER LIMIT INCREASED FROM 1425 TO 1600 PSIA
MARGIN FOR HPOT TDT MCF MONITOR TOO TIGHT IN ENGINE START PHASE.	MCF, RESULTING IN MISSION ABORT, MAY BE POSTED FOR OTHERWISE SATISFACTORY TDT TEMPERATURE PROFILE.	INCREASE ACTUATION TIME FROM 3.5 TO 3.8 SECONDS.
FIX FOR PRESTART REDLINE REDUNDANCY MONITOR	INHIBIT RESPONSE OK BUT NO FID POSTED IF HPFT TDT FAILURE OCCURS DURING START PREPARATION PHASE	INCLUDE FIX FOR HPFT TDT PRESTART MONITOR.
CHANGE CONTROLLER ON ME-2 FROM F5 TO F4	HARDWARE/SOFTWARE MUST BE COMPATIBLE	MODIFY SOFTWARE TO ENSURE COMPATIBILITY
RECOVERABLE POWER TRANSIENT (DEPENDING UPON TIME OF OCCURRENCE) CAN CAUSE SINGLE POINT FAILURE	1) PREMATURE SHUTDOWN OF NORMALLY FUNCTIONING ENGINE 2) POTENTIAL BYPASS OF CONTROL ENGINE FUNCTION	SOFTWARE CHANGE TO 1) USE TIME REFERENCE EXISTING AT ONSET OF POWER TRANSIENT 2) INITIALIZE VALUES OF VALVE COMMANDS TO CURRENT POSITION

4.4.2 SSME CONTROLLER RESPONSE, ACCURACY, AND STABILITY - Control stability and dynamic response were satisfactory during the closed loop operation of the controller. The controller errors in chamber pressure and mixture ratio were within the accuracy of the data used to make the calculation.

Examination of the fuel and oxidizer preburner valve positions, chamber pressure, and fuel flow shows no oscillations in the steady state nor any unexpected overshoots during throttling. These time responses agree well with previous tests and analyses and indicate adequate stability and no unusual transient response. Figures 4.4.2-1 through 4.4.2-3 show a typical chamber pressure response during mainstage operation including MAX Q and 3G throttling for ME-1. These traces are similar to those obtained on ME-2 and ME-3.

In postflight data examination, the main engine chamber pressure contained oscillations of 15 psi peak to peak during mainstage up-thrust operation of ME-2. A new controller, F4, had been mounted on ME-2 and was used for the STS-4 mission. Similar oscillations have been seen on this controller during all previous tests over the last three years with no increase in oscillation magnitudes. Since the oscillations have no negative effect on vehicle performance, the F4 controller will remain on ME-2 for the STS-5 mission.

Figure 4.4.2-4 shows that the controller held the mean mixture ratio close to the controlled value of 6.0. An independent calculation of the mixture ratio, using the algorithm in the controller and the mean value of the measurement, shows good results. Table 4.4.2-1 shows the results of this calculation over a time period from 10 seconds to MECO.

TABLE 4.4.2-1 MIXTURE RATIO CONTROL DURING STEADY-STATE OPERATION

ENGINE NO.	CALCULATED MR	MR DEVIATION (%)
ME-1	5.9981	-.032
ME-2	5.9982	-.030
ME-3	5.9988	-.021

4.4.3 SSME CONTROLLER HARDWARE PERFORMANCE - The controller hardware performance is considered satisfactory. Its performance, as in the previous software task, can best be determined by examination of any reported FIDs. There were no FIDs nor SSME system problems relating to controller hardware performance reported during the mission. All commands sent to the controller were accepted and processed in the normal sequence with no command rejections encountered.

Controller internal pressures remained between 21 and 22 psi for all three controllers throughout the flight. There were no pre-to-post flight differentials for any controller.

The controller temperatures were acceptable. It was noted that during the on-orbit tail-to-sun attitude, the controller internal temperatures warmed up to a maximum of 130 deg F. During the belly-to-sun attitude internal controller temperatures dropped to a minimum of 15 deg F.

It is significant that only routine testing and no maintenance were performed on the ME-1 and ME-3 controllers between STS-3 and STS-4. However, it was necessary to remove the F5 controller from ME-2 following the STS-4 tanking test and replace it with F4 which supported the STS-4 mission satisfactorily. F5 was subsequently shipped to Honeywell-Florida for failure analysis and repair.

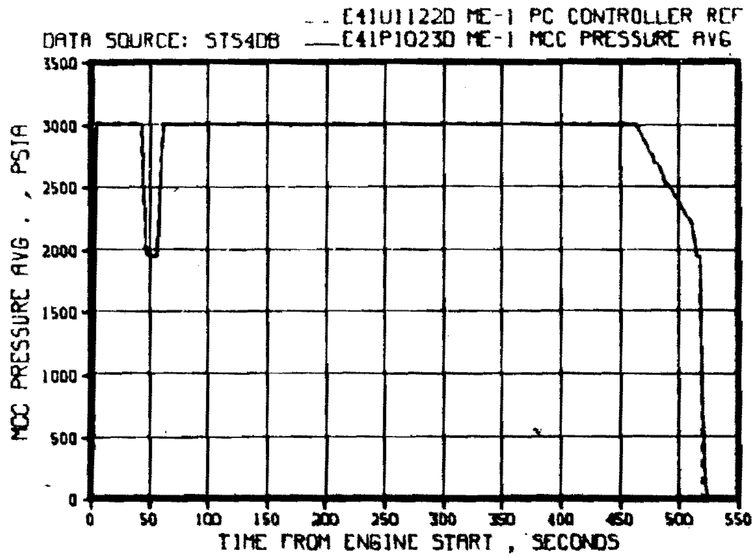


FIGURE 4.4.2-1 MAIN CHAMBER PRESSURE CONTROL

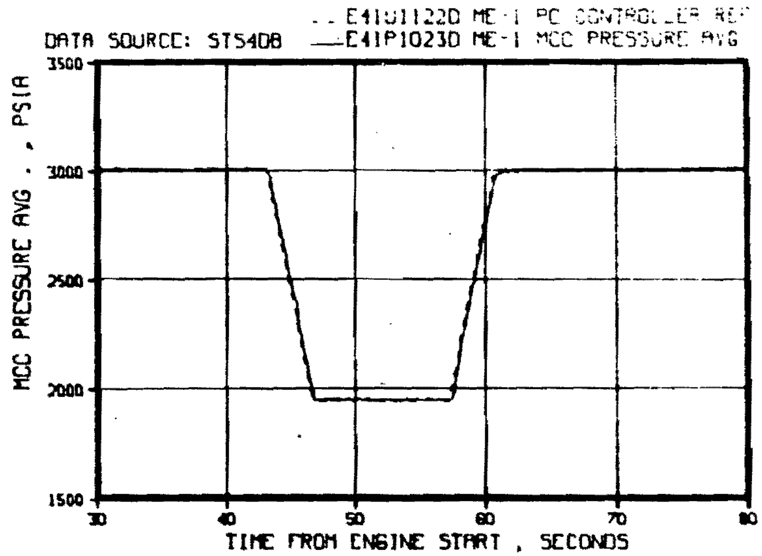


FIGURE 4.4.2-2 MAIN CHAMBER PRESSURE CONTROL AT MAX-Q

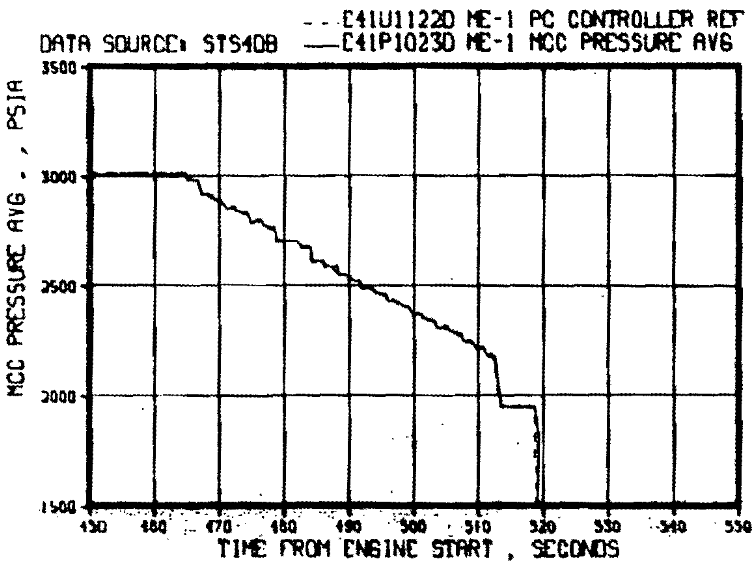


FIGURE 4.4.2-3 MAIN CHAMBER PRESSURE CONTROL AT 3G

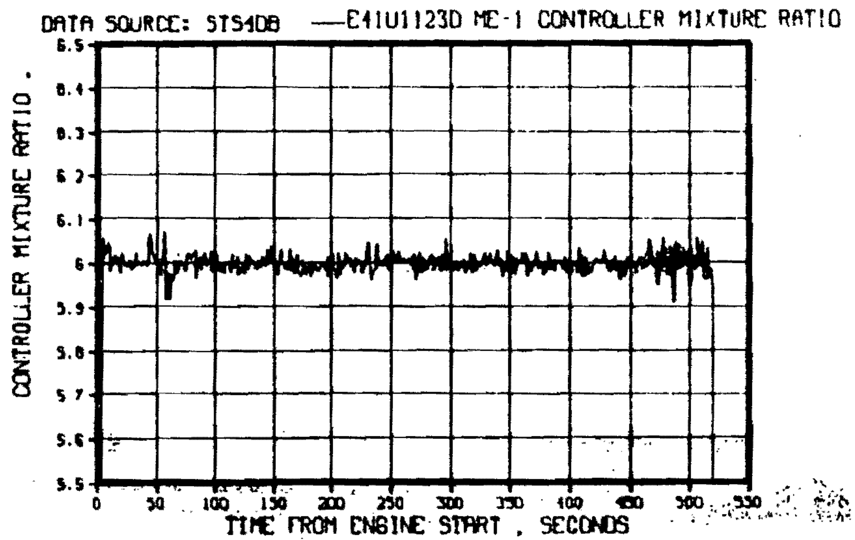


FIGURE 4.4.2-4 CONTROLLER MIXTURE RATIO

4.5.0 SSME THERMAL ASSESSMENT - The STS-4 thermal data appear valid and within the expected ranges. Only parameters determined to be malfunctioning yielded data outside appropriate scales. Most measurements followed established trends based on STS-1, STS-2, and STS-3, with the exception of the nozzle surface temperature parameters which were significantly lower.

This phenomenon of lower nozzle surface temperatures was the only STS-4 issue requiring thermal related engineering support beyond data review. See Section 4.5.3.

Particle emission from the aft end of the Orbiter in the area of the main engines was observed during the tail to sun attitude on STS-3. No such particles were observed on STS-4. This confirms the belief that the particles were due to oxygen entrapment in the feedlines to the main engines due to the pneumatic cutoff of ME-3. Performance of the main engines (specifically ME-3) was not affected during STS-4 due to this occurrence on STS-3.

STS-4 landing occurred on a concrete runway, resulting in a smaller amount of loose debris being kicked up into the air around the Orbiter during landing and rollout. This caused a favorable lighter dusting of nozzle surfaces than noted during previous postflight inspections.

Prelaunch thermal conditioning and cleansing purges were nominal. No events were encountered as in STS-3 with the water contamination of the GN2 purge. The STS-3 event was an individual isolated case with no expectations for repeatability.

The engine component surface temperatures were below allowable upper limits and were nominal. Specifically, controller temperatures, valve and valve actuator surface temperatures, powerhead surface temperatures, and nozzle surface temperatures were within allowable limits. The engine compartment (aft fuselage) environment was cool and benign, between 30 and 70 deg F during the majority of engine operation.

4.5.1 THERMAL ASSESSMENT DURING CHILLDOWN - Thermal evaluation of the three engines during chilldown showed no anomalous results. No structural temperature limits were violated. A comparison of the ambient engine compartment bulk air temperatures on STS-4 with STS-3 shows them to be almost identical as given by vehicle measurements. Figure 4.5.1-1 shows STS-4 values.

Engine components not in direct contact with the cryogenic fluids reflected the bulk air temperature changes in chilldown, as expected. Controller internal temperature (Figure 4.5.1-2) and power head surface temperature (Figure 4.5.1-3) can be compared with the bulk air temperature environment (Figure 4.5.1-1) to note that the trends are similar.

MFV and MOV skin temperatures (see Figure 4.5.1-4) responded to introduction of propellant to the engine, stopping at the closed valve surfaces. The MFV outboard side surface temperature was cooler than the corresponding MOV measurement partially due to the fact that LH2 is cooler than LO2 by approximately 150 deg F. The relatively slower response of the MOV parameter was due to a longer thermal path from the LO2 to the thermocouple location. This also partially contributed to the temperature difference between the two parameters.

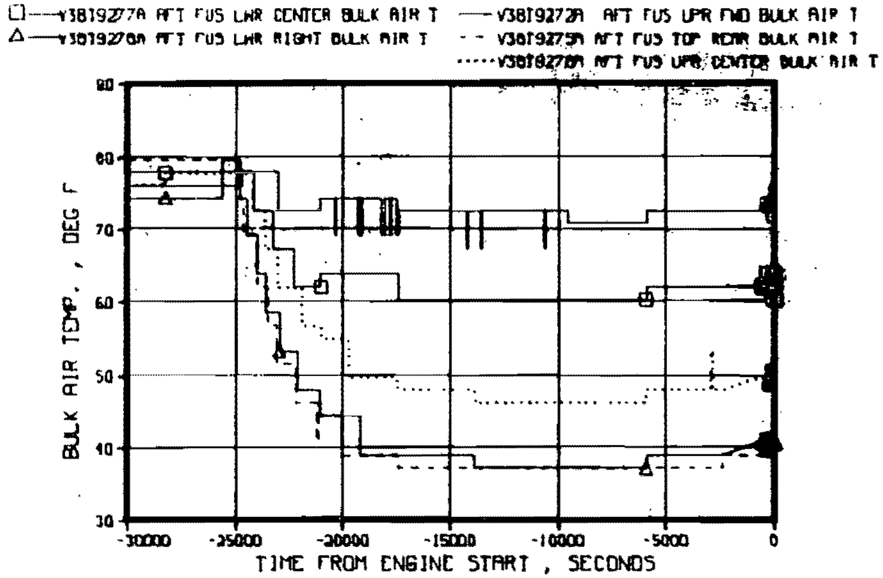


FIGURE 4.5.1-1 BULK AIR TEMPERATURES DURING START PREP.

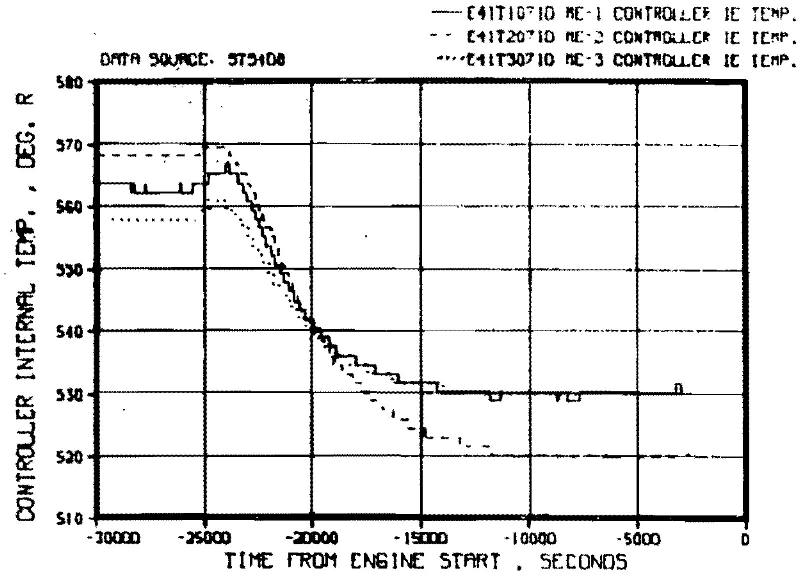


FIGURE 4.5.1-2 CONTROLLER INTERNAL TEMPERATURES DURING START PREP.

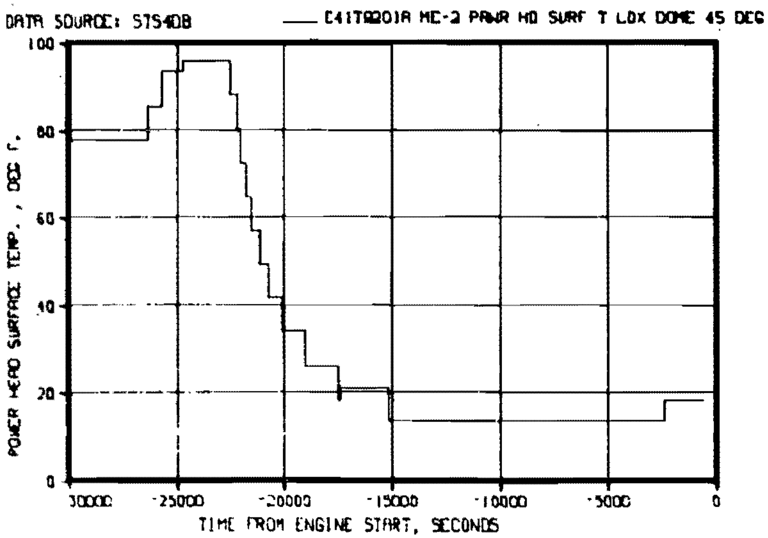


FIGURE 4.5.1-3 POWER HEAD SURFACE TEMPERATURE

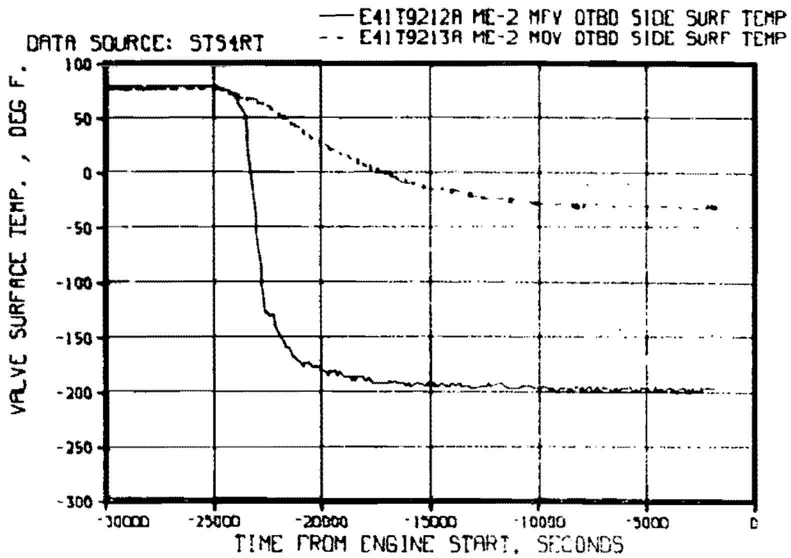


FIGURE 4.5.1-4 VALVE SURFACE TEMPERATURE

With a STS-4 morning launch time, nozzle surface temperatures were not influenced by a solar heating effect. The attitude of the Orbiter on the launch pad is tail to south, meaning that ME-3, mounted on the starboard side, would be on the eastern side of the vehicle towards the morning sun. ME-3 was lightly instrumented and so a parameter on the east side of ME-2 (E41T9246, Nozzle Temperature Aft Manifold Side 135 degrees) was selected which had the best view factor of any nozzle surface temperature measurement. Figure 4.5.1-5 shows the data from this thermocouple during prelaunch. No trend of increasing temperature was seen, and the temperature was steady between two discrete output values.

4.5.2 ASCENT ENGINE COMPONENT TEMPERATURES - Engine component temperatures within the engine compartment remained within allowable limits during ascent. Local environmental temperatures within the aft fuselage (engine compartment) are shown in Figure 4.5.2-1. After an initial decrease due to the circulation of nitrogen atmosphere over the mostly cold components, the nitrogen gradually bled out of the aft fuselage, leaving the environment at nominal temperatures, between 20 and 70 deg F.

Surface temperatures on the PCA and three of the four valve actuators each stayed within a narrow and allowable temperature band during ascent as seen in Table 4.5.2-1.

TABLE 4.5.2-1 ACTUATOR SURFACE TEMPERATURES DURING ASCENT

T/C LOCATION	MEASUREMENT NUMBER	STS-3 INITIAL (DEG F)	STS-3 MAXIMUM (DEG F)	STS-4 INITIAL (DEG F)	STS-4 MAXIMUM (DEG F)
ME-2 MFV ACT SURFACE	E41T9203A	58	75	49	70
ME-2 MOV ACT SURFACE	E41T9204A	54	81	60	84
ME-2 CCVA SURFACE	E41T9206A	--*	--*	55	97
ME-2 FPOV ACT SURFACE	E41T9208A	63	98	67	100
ME-2 OPOV ACT SURFACE	E41T9209A	--*	--*	70	102

OPERATIONAL ALLOWABLE IS NOT BASED ON SURFACE TEMPERATURES BUT ON FLUID INTERFACE TEMPERATURES AND COMPARTMENT TEMPERATURES.

* NOT AVAILABLE ON STS-3

The maximum allowable temperature for the controller is 175 deg F during active operation based on internal temperatures. Engine operational controller internal temperature data shown in Figure 4.5.2-2 show the internal electronics package temperatures for all three engines. All three curves remained below 73 deg F for the duration of the flight. The warmest position in each of the controller assemblies was the power supply, measured as parameters E41T1150A, 2150A, and 3150A. All three temperatures remained steady and were below 105 deg F.

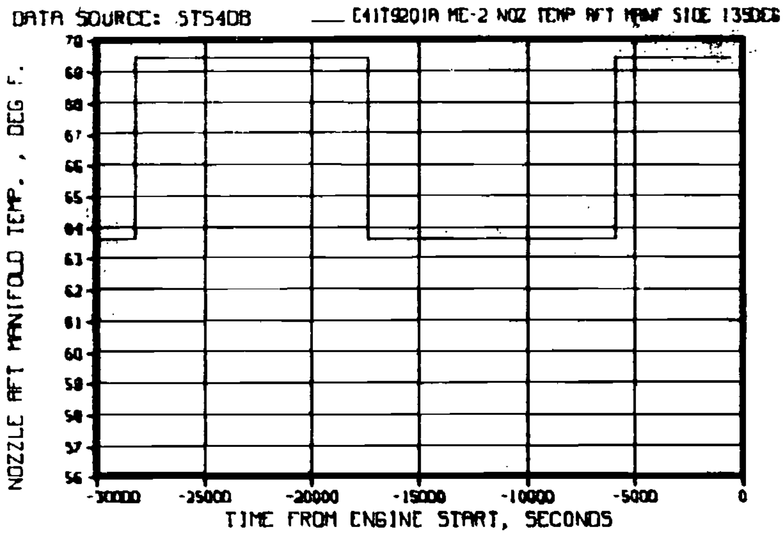


FIGURE 4.5.1-5 NOZZLE AFT MANIFOLD TEMPERATURE

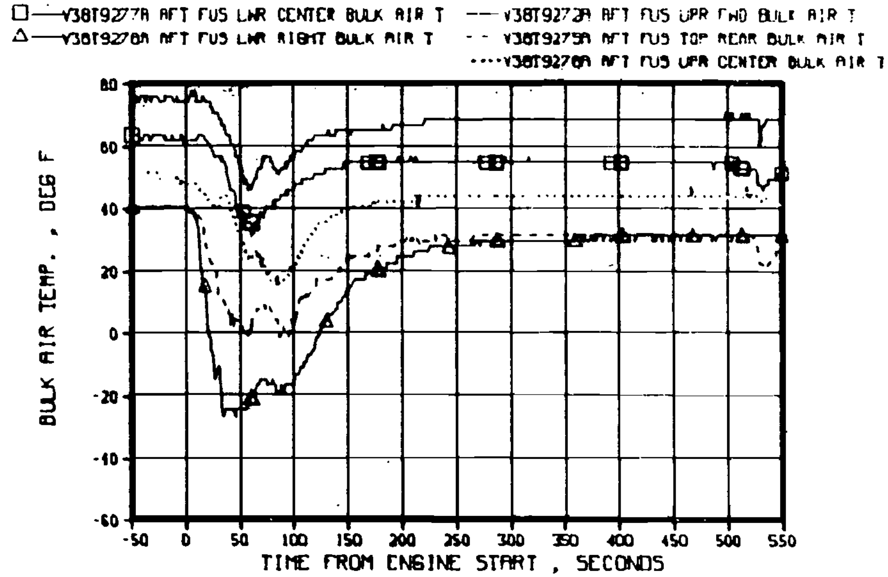


FIGURE 4.5.2-1 BULK AIR TEMPERATURES

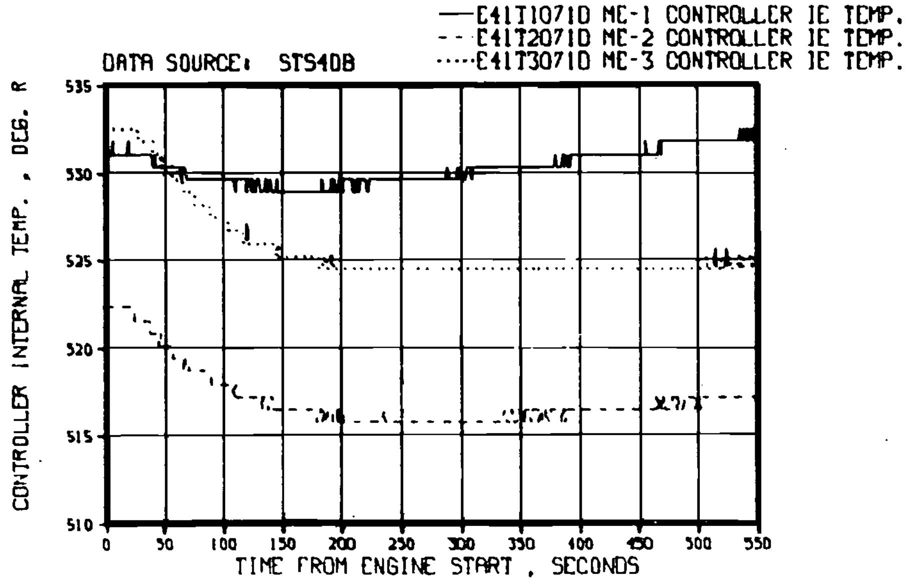


FIGURE 4.5.2-2 CONTROLLER INTERNAL TEMPERATURES.

Table 4.5.2-2 compares engine component surface temperatures with STS-3. These measurements were smooth and largely similar to STS-3 data profiles. The exception was the MFV outboard side temperature parameter. This measurement continued to show some erratic behavior as was noted during STS-3. The mainstage value was warmer than previous flight experience by approximately 20 deg, a likely indication of partial unbonding of the thermocouple. This parameter should be regarded with caution in the future even though the data appear to be reasonably valid.

TABLE 4.5.2-2 ENGINE COMPONENT SURFACE TEMPERATURES

LOCATION	MEASUREMENT NUMBER	STS-3 40 SEC (DEG F)	STS-3 M/S* (DEG F)	STS-4 40 SEC (DEG F)	STS-4 M/S* (DEG F)
ME-2 PWR HD LO2 DOME	E41T9201A	- 70	- 4	- 65	0
ME-2 PCA SURF TEMP	E41T9202A	--*	--*	66	84
ME-2 MFV OTBD SIDE	E41T9212A	-270	-298	-210	-275
ME-2 MOV OTBD SIDE	E41T9213A	-225	-262	-225	-260

* M/S - MAINSTAGE
--* - NOT AVAILABLE

4.5.3 <u>ASCENT NOZZLE STRUCTURAL TEMPERATURES</u> – A total of fifteen thermocouples were mounted on nozzle surfaces and drain lines to measure the hardware temperatures. Twelve of these were positioned to provide information useful during the ascent phase and the remaining three for information on areas significant during reentry. Table 4.5.3-1 gives a comparison of the ascent thermocouple measurements.

Typical behavior of the nozzle thermocouples on STS-4 was to follow previous flight experience until approximately 100 sec and then decrease in magnitude or only slowly increase, distinctly different from the rise noted in STS-1, STS-2, and STS-3. See Figures 4.5.3-1 through -3. The divergence at approximately 100 sec can be easily noted, as also the tendency for the slopes to become similar or more parallel beginning at approximately 250 to 300 sec.

These lower nozzle temperatures can be explained by the water soaking of the exposed nozzle insulation during the prelaunch rainstorm. The nozzle insulation is a fine metal mesh that can retain water. Winds and Orbiter drainoff can be assumed to provide a good dispersion of rainwater onto the three nozzles. The combined effect of increased heat capacity of the insulation due to the addition of water (which overpowered the increased thermal conductivity effects) and the energy absorbed in evaporation of that water resulted in surface temperatures that were lower than on previous flights.

The delayed effect until it can be noticed at approximately 100 sec can be attributed to thermal soakback time and the influence of local atmospheric pressure. Atmospheric pressure decreases with altitude and asymptotically approached 0 psia at 100 sec. The boiling point of water is lower at lower pressures than at higher pressures, so the vaporization rate of the water increased with altitude until approximately 100 sec. Water can be vaporized at a faster rate at 100 sec than immediately after liftoff and therefore the energy absorption effect of the water would be more significant at 100 sec.

TABLE 4.5.3-1 ASCENT NOZZLE SURFACE TEMPERATURES (DEGREES FAHRENHEIT)

NUMBER	ENG	LOCATION	STS-4 FLIGHT 100 SEC	250 SEC	500 SEC	MAX	STS-3 MAX	ALLOWED
E41T9123	ME-1	H/B 2, 240 DEG, SIDE	52	53	83	90	183	758
E41T9127	ME-1	H/B 5, 260 DEG, SIDE	68	28	-18	68	58	515
E41T9129	ME-1	H/B 8, 260 DEG, SIDE	70	30	0	93	185	471
E41T9143	ME-1	STA 7, 268 DEG, TUBE	430	470	420	490	520	1000
E41T9149	ME-1	AFT MANIFOLD 260 DEG, LIP	-240	-220	-240	60	60	650
E41T9150	ME-1	H/B 9, 260 DEG, SIDE	60	22	-12	103	177	430
E41T9223	ME-2	H/B 2, 135 DEG, SIDE	46	46	69	69	40	758
E41T9228	ME-2	H/B 6, 135 DEG, SIDE	70	35	-12	87	138	510
E41T9229	ME-2	H/B 8, 135 DEG, SIDE	80	46	0	92	240	471
E41T9243	ME-2	STA 7, 178 DEG, TUBE	485	490	440	500	525	1000
E41T9246	ME-2	AFT MANIFOLD 135 DEG, LIP	-240	-240	-240	60	60	650
E41T9247	ME-2	H/B 9, 132 DEG, SIDE	68	45	17	90	143	430

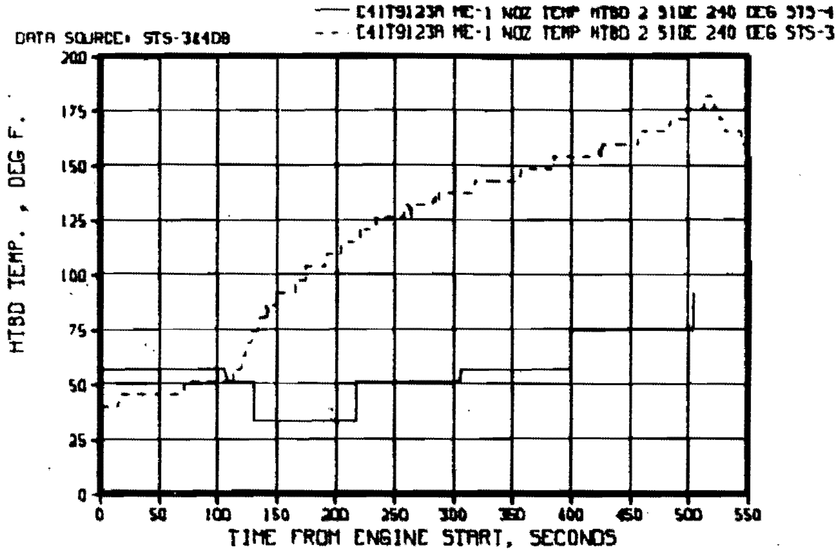


FIGURE 4.5.3-1 ME-1 NOZZLE TEMPERATURE, HATBAND 2 STS-3 & 4

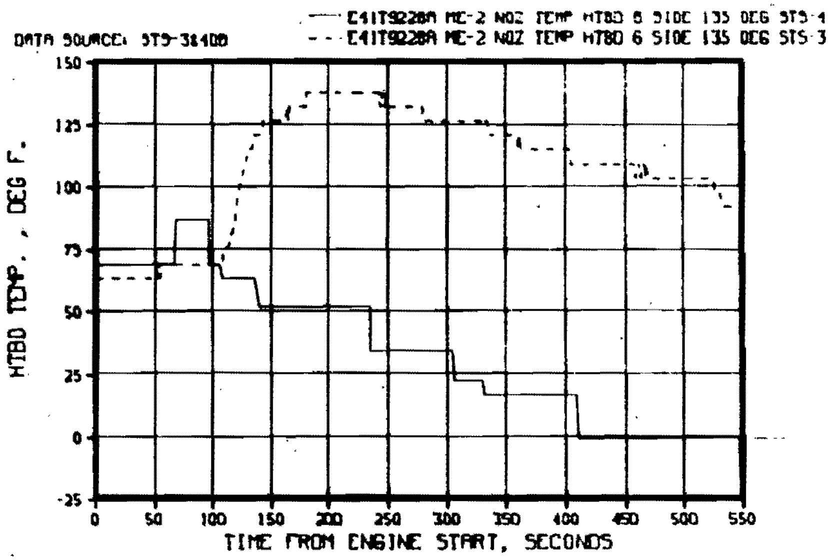


FIGURE 4.5.3-2 ME-2 NOZZLE TEMPERATURE, HATBAND 6 STS-3 & 4

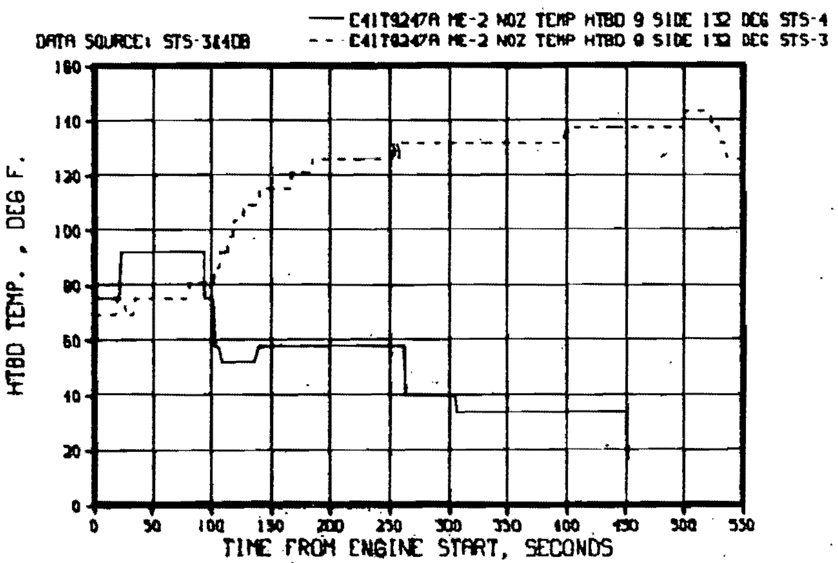


FIGURE 4.5.3-3 ME-2 NOZZLE TEMPERATURE, HATBAND 9 STS-3 & 4

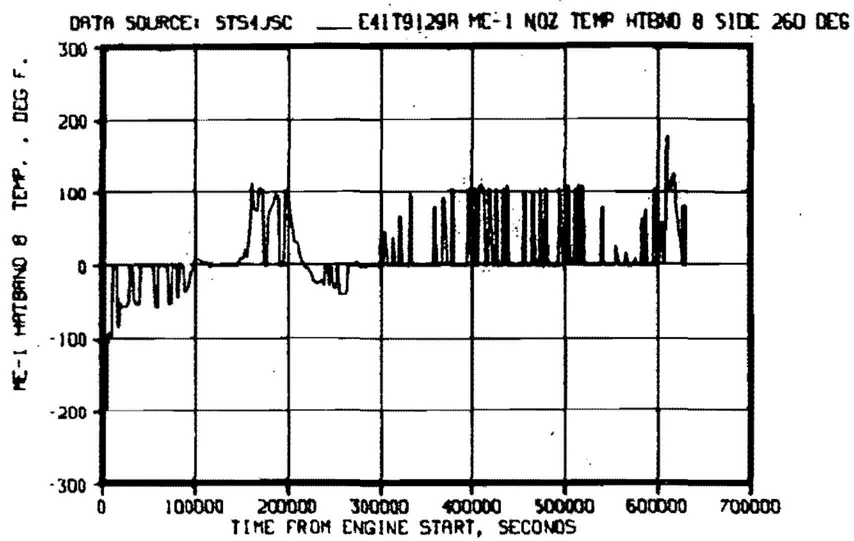


FIGURE 4.5.5-1 ME-1 HATBAND 8 TEMPERATURE

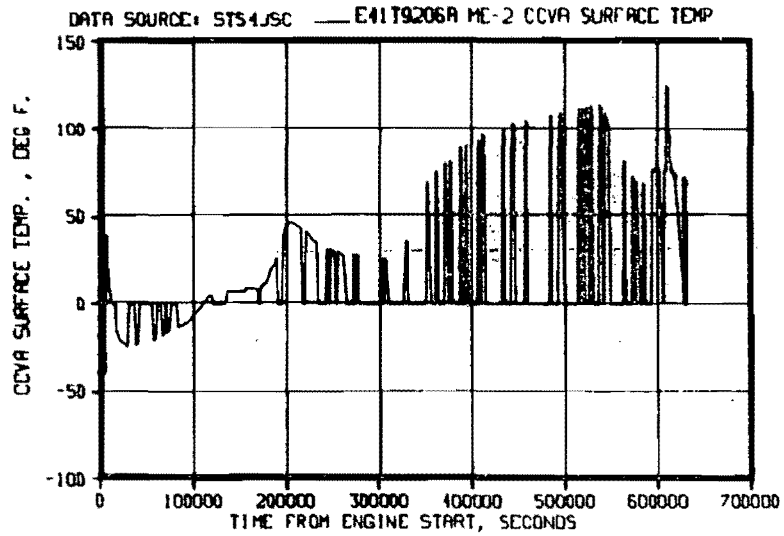


FIGURE 4.5.5-2 C C V A SURFACE TEMPERATURE

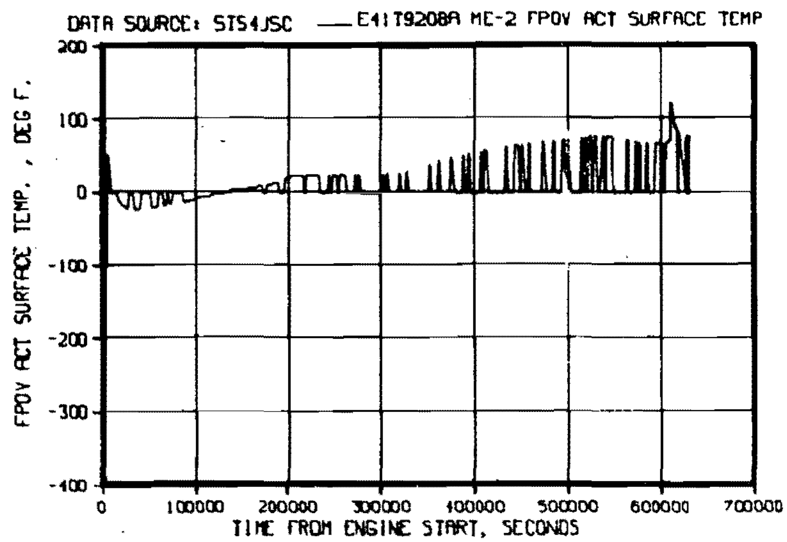


FIGURE 4.5.5-3 F P O V ACT SURFACE TEMPERATURE

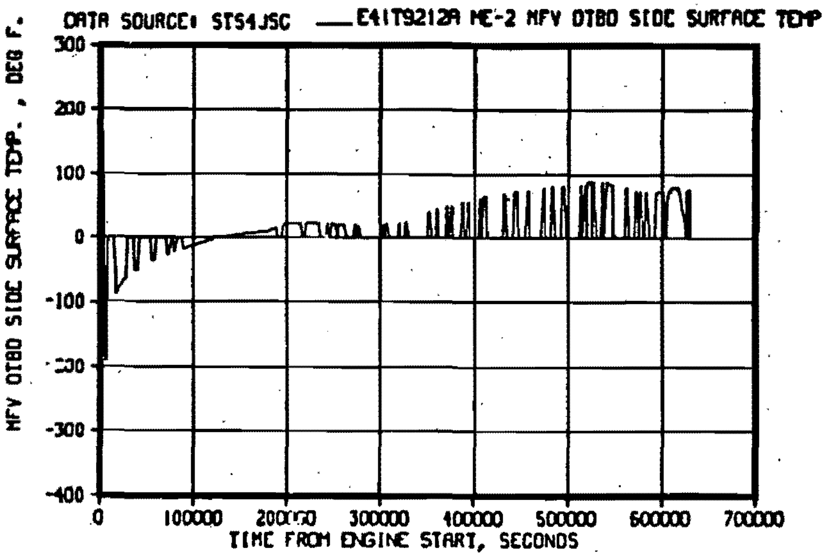


FIGURE 4.5.5-4 MFV OTBD SIDE SURFACE TEMPERATURE

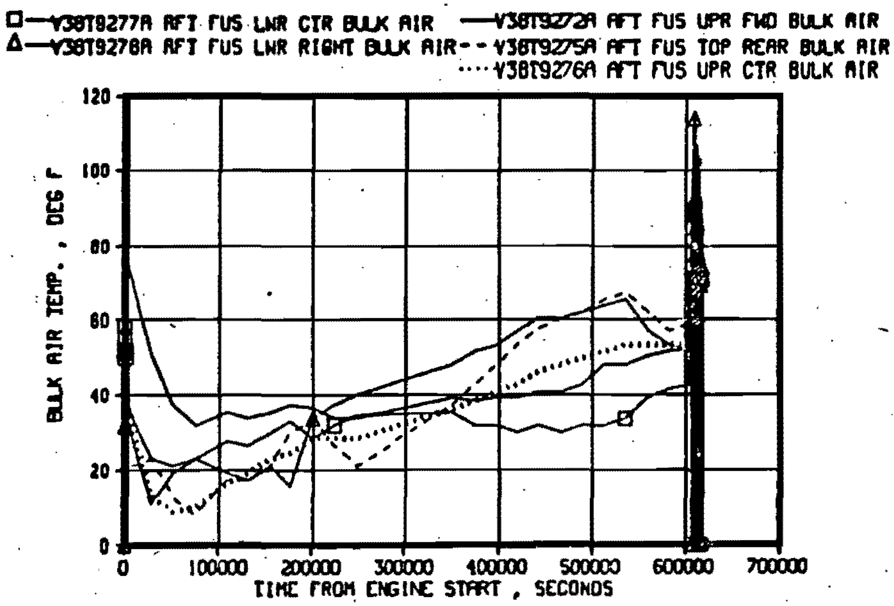


FIGURE 4.5.5-5 BULK AIR TEMPERATURES

4.5.6 REENTRY ENGINE TEMPERATURES - Reentry nozzle structural temperatures on STS-4 were not expected to be significantly different from previous flight experience. Preflight reentry aeroheating predictions indicated a slight (less than 2%) increase in heat load over STS-3 values. Although minor repairs were made to nozzle insulation following STS-3, no specific cleaning effect was undertaken on the insulation. The expectation from this fact is that as the insulation becomes darkened and discolored, the radiative absorptivity will increase, increasing the heat absorbed and thus the nozzle temperature.

The locations of the four highest STS-4 SSME nozzle reentry temperatures were the same as on STS-3. See Table 4.5.6-1 for a tabulation and comparisons of nozzle temperatures. The similar locations of the highest readings show the repeatability of the reentry heating effects, demonstrating predictable behavior and response.

TABLE 4.5.6-1 DESCENT NOZZLE SURFACE TEMPERATURES (DEG F)

NUMBER	ENGINE	LOCATION	STS-2	STS-3 TEMPERATURE	STS-4	ALLOWABLE
E41T9238	ME-2	H/B B, 315 DEG, SIDE	390	315	230	1200
E41T9255	ME-2	AFT MAN, 315 DEG, LIP	515	475	430	1200
E41T9266	ME-2	AFT BAY, 315 DEG, SIDE	605	580	620	1200
E41T9149	ME-1	AFT MAN, 260 DEG, LIP	380	380	340	1200
E41T9246	ME-2	AFT MAN, 135 DEG, LIP	405	370	360	1200

Nozzle surface temperatures during STS-4 reentry exhibited similar response profiles to earlier flights. The parameter with the highest magnitude of response, E41T9266, continues to be the only measurement with twin peaks near the point of maximum temperature. Maximum temperatures were in general less than STS-3, which were less than STS-2. Assuming the reentry aeroheating environment prediction to be accurate, it leads to the conclusion that the nozzle insulation becomes more effective with continued use. The effect of contaminants within the insulation (SRB exhaust products, dust from touchdown on unpaved runways) appears to be decreasing the thermal conductivity of the insulation enough to overcompensate for the higher heat load and increased radiative absorptivity.

In response to the magnitude of reentry nozzle temperatures on the first three flights, an initial assessment was made prior to STS-4 as to potential reduction of nozzle insulation. STS-4 data, because of the repeatability and increasing effectivity of the insulation, strengthens the reasoning for a reduction of insulation for reentry.

Engine temperatures in the aft fuselage during reentry were much less affected than the exposed nozzle surfaces, as expected. Temperatures in the aft fuselage rose between 28 and 40 degrees, partially due to the reentry heating and partially due to landing in a warm desert environment. The data definition in the reentry and landing time period was fine enough to notice the effects of warm hydraulic fluid circulating through the valve actuators. (The hydraulic system for the main engines is activated for a short time after landing to reposition the nozzles for drainage and access purposes).

In conclusion, all hardware thermocouples appear to have functioned accurately during the reentry and landing time period. All temperatures are well below allowable limits.

4.6.0 SSME DYNAMICS EVALUATION - This section reports the evaluation of 18 vibration measurements on ME-1, ME-2, and ME-3. (See Section 4.3.2 for further discussion of FASCOS instrumentation.) The objective of the evaluation was to verify that the SSME turbopumps operated within established vibration limits.

Composite and synchronous vibration levels measured on the HPOTP of ME-1 were slightly higher than noted on previous flights. Measurements on the other two engines and the HPFTP were similar to those levels measured during previous flights. Tables 4.6.0-1 through 4.6.0-3 compare STS-4 with STS-1, STS-2 and STS-3 data.

TABLE 4.6.0-1 SSME DYNAMIC DATA COMPARISON (ME-1)

LOCATION	MAX VIB (GRMS)	STS-4	STS-3	STS-2	STS-1
HPOTP PBP 45-1	COMP	(1)7.0	5.8	4.8	4.0
	SYNCH	6.0	5.0	4.3	3.9
HPOTP PBP 135-1	COMP	6.5	5.5	5.2	4.2
	SYNCH	5.9	5.0	5.0	4.0
HPOTP PBP 135-3	COMP	6.0	5.0	5.5	5.0
	SYNCH	5.3	4.7	5.0	4.1
HPOTP PBP 180-1	COMP	4.9	4.1	3.5	3.9
	SYNCH	4.1	3.6	3.0	3.0
HPFTP RADIAL 90	COMP	(2)4.0	4.1	4.8	-
	SYNCH	2.9	4.0	4.5	-
HPFTP RADIAL 180	COMP	(2)4.5	7.0	7.2	6.2
	SYNCH	3.9	6.4	5.8	5.6

(1) NOISY @ S + 240 SECONDS
(2) HPFTP 2009

TABLE 4.6.0-2 SSME DYNAMIC DATA COMPARISON (ME-2)

LOCATION	MAX VIB (GRMS)	STS-4	STS-3	STS-2	STS-1
HPOTP PBP 45-1	COMP	3.1	3.0	2.5	2.5
	SYNCH	2.5	2.6	2.0	2.1
HPOTP PBP 135-1	COMP	4.0	3.8	3.4	3.8
	SYNCH	3.8	3.7	3.1	3.2
HPOTP PBP 135-3	COMP	3.9	3.7	3.5	3.5
	SYNCH	3.3	3.3	3.0	3.1
HPOTP PBP 180-1	COMP	(1) 3.1	3.0	3.0	3.0
	SYNCH	1.4	1.4	1.0	1.2
HPFTP RADIAL 90	COMP	BAD	2.3	2.3	-
	SYNCH	BAD	1.3	0.8	-
HPFTP RADIAL 180	COMP	(1) 2.0	1.8	1.8	2.2
	SYNCH	.7	1.2	0.5	1.8

(1) NOISY, INTERMITTENTLY BAD

TABLE 4.6.0-3 SSME DYNAMIC DATA COMPARISON (ME-3)

LOCATION	MAX VIB (GRMS)	STS-4	STS-3	STS-2	STS-1
HPOTP	COMP	(1) 4.0	4.8	3.2	3.0
PBP 45-1	SYNCH	2.0	2.0	1.0	1.2
HPOTP	COMP	BAD	3.8	4.1	4.9
PBP 135-1	SYNCH	BAD	1.3	1.8	3.8
HPOTP	COMP	BAD	3.2	3.4	4.5
PBP 135-3	SYNCH	BAD	1.4	1.8	3.0
HPOTP	COMP	2.7	2.5	3.0	3.1
PBP 180-1	SYNCH	2.0	1.5	1.5	2.1
HPFTP	COMP	3.1	4.0	3.5	-
RADIAL 90	SYNCH	2.5	2.5	2.1	-
HPFTP	COMP	3.1	2.8	3.5	3.2
RADIAL 180	SYNCH	2.1	2.3	2.7	2.0

(1) NOISY

8.0 RANGE SAFETY SYSTEM

8.1 INTRODUCTION - This section reports data analysis results for the Shuttle Range Safety System (SRSS) for STS-4.

8.2 DATA SOURCES - Data used in the analysis of the SRSS were extracted from the following data bases in the MSFC U1100 Computer: STS4RT, STS4DB, and STS4JSC.

There were cases of disagreement between data from the three sources. RT and DB agreed on the two most troublesome data discrepancies. These two discrepancies were an indicated increase in LH SRB RSS battery current and an ET Decoder arm output, occurring at a time (121.5 sec) when their respective MDM's were just recovering from a momentary synchronization loss.

Careful analysis of each SRSS measurement using all available data sources showed that the above discrepancies were data, rather than SRSS hardware problems.

8.3 SHUTTLE RANGE SAFETY SYSTEM ANALYSIS RESULTS - The following tables show performance measurements for the SRSS. Event times are based on STS4DB (data base) times which were referenced to the first full second before SRB ignition command time (STS4DB reference is 1982:178:14:59:59.0 GMT. SRB ignition command time is 1982:178:14:59:59.793 GMT).

The following SRB Range Safety System (RSS) event measurements were evaluated for STS-4 over the period from T-400 seconds to SRB separation. All measurements were normal.

MSID	DESCRIPTION	COMMENTS
LEFT SRB		
B55X1869X	S&A SAFED	S&A DEVICE WAS ARMED AT T-297.6 SEC.
B55X1870X	S&A ARMED	AND SAFED AT T+124.55 SEC.
B55X1881X	ARM INHIBIT A	INHIBIT WAS REMOVED AT T-9.7 SEC.
B55X1882X	ARM INHIBIT B	INHIBIT WAS REMOVED AT T-8.7 SEC.
B55X1871X	DECODER A POWER ON	ON UNTIL T+124.72 SEC., OFF THEREAFTER
B55X1872X	DECODER B POWER ON	ON UNTIL T+124.72 SEC., OFF THEREAFTER
B55X1877X	DECODER ARM A	OFF FOR FULL FLIGHT PERIOD EXCEPT FOR TURNOFF TRANSIENT AT 124.72 SEC. (NORMAL)
B55X1878X	DECODER ARM B	OFF FOR FULL FLIGHT PERIOD
B55X1879X	DECODER FIRE A	OFF FOR FULL FLIGHT PERIOD EXCEPT FOR TURNOFF TRANSIENT AT 124.72 SEC. (NORMAL)
B55X1880X	DECODER FIRE B	OFF FOR FULL FLIGHT PERIOD
B55X1865X	PIC A ARMED	OFF THROUGHOUT PERIOD EVALUATED
B55X1866X	PIC B ARMED	OFF THROUGHOUT PERIOD EVALUATED
B55X1867X	PIC A FIRED	OFF THROUGHOUT PERIOD EVALUATED
B55X1868X	PIC B FIRED	OFF THROUGHOUT PERIOD EVALUATED
B55X1875X	LOAD TEST A	OFF THROUGHOUT PERIOD EVALUATED
B55X1876X	LOAD TEST B	OFF THROUGHOUT PERIOD EVALUATED
B55X1873X	RES. TEST A	OFF THROUGHOUT PERIOD EVALUATED
B55X1874X	RES. TEST B	OFF THROUGHOUT PERIOD EVALUATED
RIGHT SRB		
B55X2869X	S&A SAFED	S&A DEVICE WAS ARMED AT T-297.6 SEC.
B55X2870X	S&A ARMED	AND SAFED AT T+124.55 SEC.
B55X2881X	ARM INHIBIT A	INHIBITS WERE REMOVED AT T-9.7 SEC.
B55X2882X	ARM INHIBIT B	
B55X2871X	DECODER A POWER ON	ON UNTIL T+124.72 SEC., OFF THEREAFTER
B55X2872X	DECODER B POWER ON	ON UNTIL T+124.72 SEC., OFF THEREAFTER
B55X2877X	DECODER ARM A	OFF FOR FULL FLIGHT PERIOD EXCEPT FOR TURNOFF TRANSIENT AT 124.72 SEC. (NORMAL)
B55X2878X	DECODER ARM B	OFF FOR FULL FLIGHT PERIOD EXCEPT FOR TURNOFF TRANSIENT AT 124.72 SEC. (NORMAL)
B55X2879X	DECODER FIRE A	OFF FOR FULL FLIGHT PERIOD EXCEPT FOR TURNOFF TRANSIENT AT 124.72 SEC. (NORMAL)
B55X2880X	DECODER FIRE B	OFF FOR FULL FLIGHT PERIOD EXCEPT FOR TURNOFF TRANSIENT AT 124.72 SEC. (NORMAL)
B55X2865X	PIC A ARMED	OFF THROUGHOUT PERIOD EVALUATED
B55X2866X	PIC B ARMED	OFF THROUGHOUT PERIOD EVALUATED
B55X2867X	PIC A FIRED	OFF THROUGHOUT PERIOD EVALUATED
B55X2868X	PIC B FIRED	OFF THROUGHOUT PERIOD EVALUATED
B55X2875X	LOAD TEST A	OFF THROUGHOUT PERIOD EVALUATED
B55X2876X	LOAD TEST B	OFF THROUGHOUT PERIOD EVALUATED
B55X2873X	RES. TEST A	OFF THROUGHOUT PERIOD EVALUATED
B55X2874X	RES. TEST B	OFF THROUGHOUT PERIOD EVALUATED

The following ET RSS event measurements were evaluated for STS-4 over the period from T-400 seconds to ET separation. All measurements were normal.

MSID	DESCRIPTION	COMMENTS
T55X1869X	S&A SAFED	S&A DEVICE WAS ARMED AT T-297.6 SEC.
T55X1870X	S&A ARMED	(THE S&A DEVICE WAS NOT SAFED)
T55X1885X	ARM INHIBIT A	INHIBITS WERE REMOVED AT T-9.7 SEC.
T55X2888X	ARM INHIBIT B	
T55X1925E	DECODER POWER ON	ON THROUGHOUT PERIOD EVALUATED
T55X1931E	DECODER ARM	OFF EXCEPT FOR DATA DISCREPANCY AT 121.5 SEC.
T55X1933E	DECODER FIRE	OFF THROUGHOUT PERIOD EVALUATED
T55X1867X	PIC A FIRED	OFF THROUGHOUT PERIOD EVALUATED
T55X2868X	PIC B FIRED	OFF THROUGHOUT PERIOD EVALUATED
T55X1884X	LOAD TEST A	OFF THROUGHOUT PERIOD EVALUATED
T55X2887X	LOAD TEST B	OFF THROUGHOUT PERIOD EVALUATED
T55X1883X	RES. TEST A	OFF THROUGHOUT PERIOD EVALUATED
T55X2886X	RES. TEST B	OFF THROUGHOUT PERIOD EVALUATED

The following SRB RSS analog measurements were evaluated for STS-4 over the period from T-400 seconds to SRB separation. All measurements exhibited normal behavior. The measured values shown below are for the time period from T-400 seconds until just before the command was issued to power down the SRB RSS (approximately T+124.5 sec.).

MSID	DESCRIPTION	MEASURED VALUES
LEFT SRB		
B55V1625C	RSS BAT. A VOLTS	27.76 TO 27.84 VDC
B76V1602C	REC. BAT. B VOLTS	30.0 TO 30.08 VDC
B55C1051C	RSS BAT. A CUR.	.310 ADC: 2.14 ADC DURING S&A ROTATION (ALSO 1.46 ADC DATA DISCREPANCY AT 121.5 SEC.)
B76C1050C	REC. BAT. B CUR.	.30 TO .31 ADC
B55E1100C	SIG. STRENGTH A	3.16 TO 3.57 VDC (ALSO SEE SECTION 8.4)
B55E1101C	SIG. STRENGTH B	3.51 TO 3.75 VDC (ALSO SEE SECTION 8.4)
B55V1623C	PIC A CAP. VOLTS	0 VDC
B55V1624C	PIC B CAP. VOLTS	0 VDC
RIGHT SRB		
B55V2625C	RSS BAT. A VOLTS	28.0 TO 28.08 VDC
B76V2602C	REC. BAT. B VOLTS	30.0 TO 30.1 VDC
B55C2051C	RSS BAT. A CUR.	.300 TO .330 ADC
B76C2050C	REC. BAT. B CUR.	.280 TO .290 ADC
B55E2100C	SIG. STRENGTH A	2.67 TO 3.75 VDC (ALSO SEE SECTION 8.4)
B55E2101C	SIG. STRENGTH B	2.57 TO 3.80 VDC (ALSO SEE SECTION 8.4)
B55V2623C	PIC A CAP. VOLTS	0 VDC
B55V2624C	PIC B CAP. VOLTS	0 VDC

8.7 CONCLUSIONS - Analysis of available measurement data indicates that all SRSS hardware performed as expected during the STS-4 launch and ascent. All indications are that if it had been necessary to use the Range Safety System at any time between liftoff and ET separation, it would have performed as designed.

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