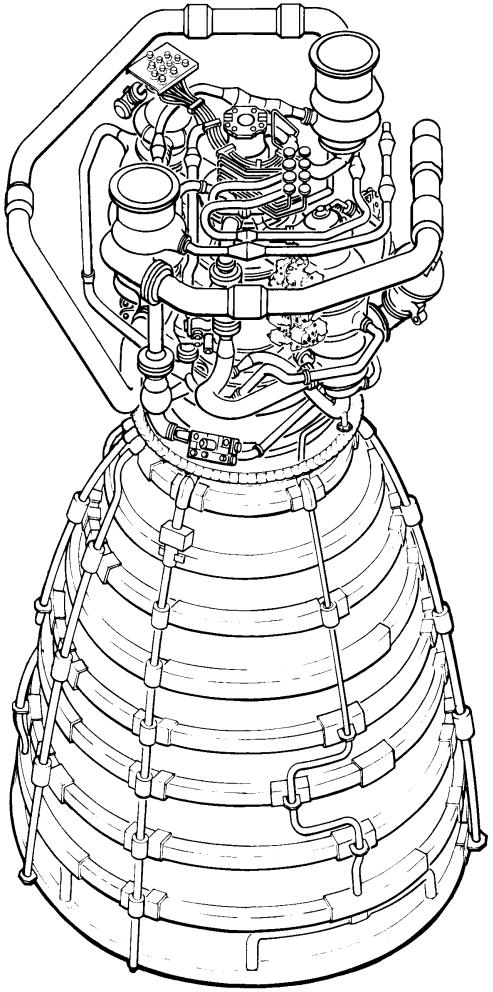


Discovery STS-105

Space Shuttle Program

SSME Flight Readiness Review

August 1, 2001

G. HOPSON
01 August 2001

Discovery STS-105

Agenda

- **Major Components**
- **Engine Performance**
- **First Flight ECPs -** None
- **Special Topics**
  - HPFTP 1st Stage Tip Seal Fretting
  - STS-105, E2044 OPB Igniter Harness Damage
- **Material Review Reassessment**

Discovery STS-105

SSME Major Components

Engine	ME-1 (2052) *Block IIA*	ME-2 (2044) *Block IIA*	ME-3 (2045) *Block IIA*
Last Hot-Fire	**STS-98**	**STS-98**	**STS-102**
Powerhead	6009	6010	6008
Main Injector	6007	4029	4026
MCC	6016	6007	6008
Nozzle	4025	2035	2031 (1)
Controller	F52	F59	F34
HPFTP	4116	4308	6016R1
LPFTP	4111	2232	6003
HPOTP	8030	8014R1	8023R1
LPOTP	6004	2229	4506

(1) Changes from last hot-fire.

Discovery STS-105

Predicted SSME Ignition Confirm Margins

Parameter	Margin Sigma		
	ME-1 (2052)	ME-2 (2044)	ME-3 (2045)
HPFTP Minimum Speed	7.0	5.4	5.9
Min/Max Ignition Pc	4.4	**a [2.8]**	4.5
Antiflood Valve Min Open	26.8	25.7	25.7
HPFTP Max Turbine Temp	4.5	5.3	6.3
HPOTP Max Turbine Temp	5.6	3.3	5.4
HPOTP Min Turbine Temp	6.2	7.2	7.1
Preburner Max Purge Pressure	26.5	26.9	27.8
POGO GOX Min/Max Pressure	4.0	4.3	4.2

a Less than 3 sigma margin. Acceptable using run-to-run database, 5.4 sigma.

Discovery STS-105

Predicted SSME Performance at 104.5% P.L.

Parameter	Sigma		
	ME-1 (2052)	ME-2 (2044)	ME-3 (2045)
HPFT Disch Temp A, Deg R	0.4	0.3	-1.0
HPFT Disch Temp B, Deg R	0.8	-0.2	-0.4
HPOT Disch Temp A, Deg R	**a [-2.5]**	2.0	-0.8
HPOT Disch Temp B, Deg R	-0.7	**b [2.8]**	-0.1
HEX Interface Temp, Deg R	-1.5	1.7	0.0
HPFTP Speed, rpm	-0.5	-0.3	-1.3
LPFTP Speed, rpm	0.3	-0.6	-0.9
HPOTP Speed, rpm	-0.2	-0.6	0.3
LPOTP Speed, rpm	0.3	-0.5	0.9
OPOV Position, %	-0.1	**c** 1.8	0.6
FPOV Position, %	**a [2.1]**	0.4	-1.5
PBP Disch Pressure, psia	-0.5	0.3	1.3
HPFTP Disch Pressure, psia	-0.7	0.0	-1.2
HPOTP Disch Pressure, psia	-1.0	-0.3	0.6
HPFTP U/N	4116	4308	6016R1
LPFTP U/N	4111	2232	6003
HPOTP U/N	8030	8014R1	8023R1
LPOTP U/N	6004	2229	4506

[ ] Exceeds database two sigma
a Low OPB injector resistance and low fuel pump efficiency
b Low performing HPOTP turbine
c OPOV oscillates in mainstage. Prediction based on average from last two flights

Discovery STS-105

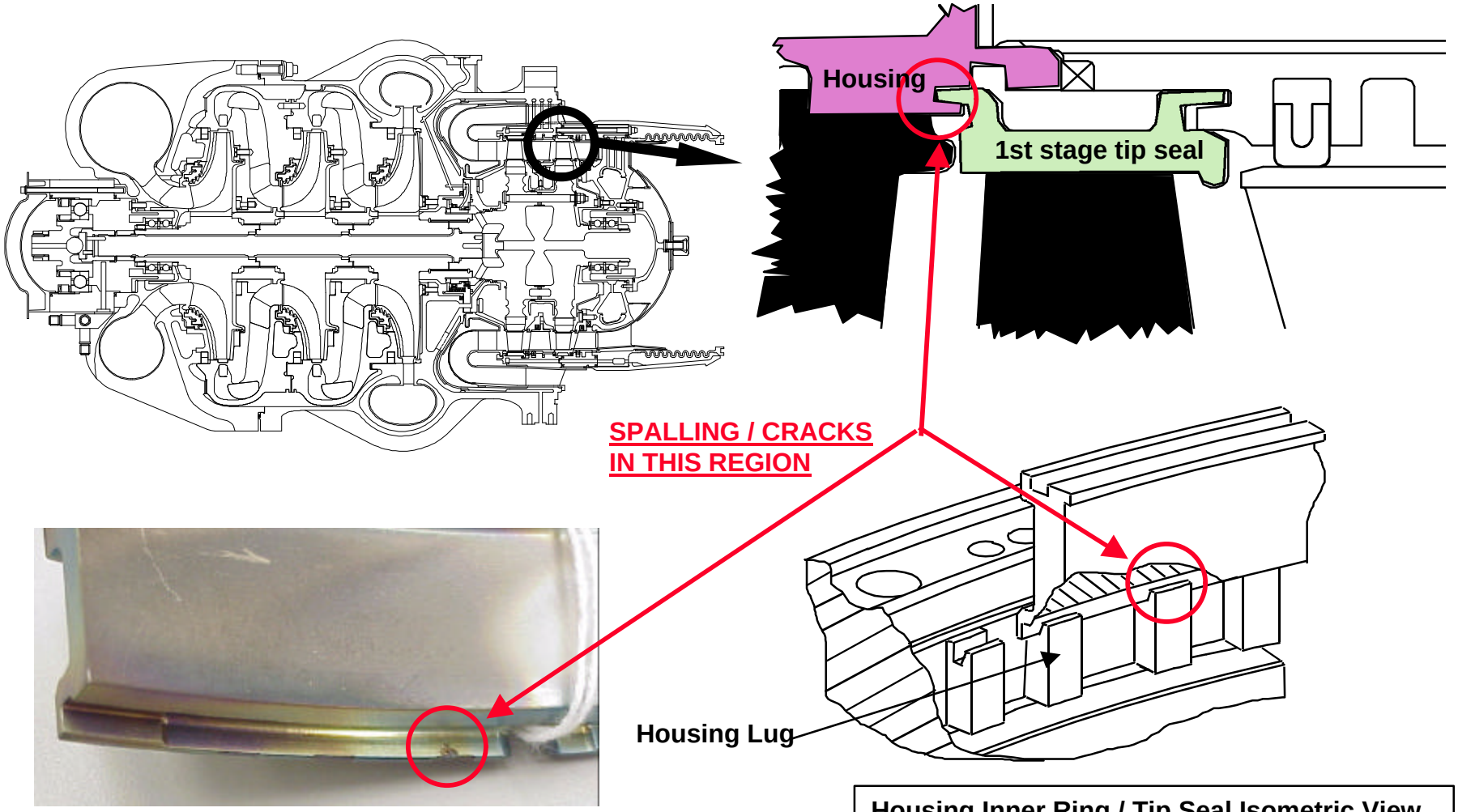
Predicted Redline Margins at 104.5% P.L.

Parameter	Margin Sigma		
	ME-1	ME-2	ME-3
HPFT Discharge Temp ChA, Deg R	5.9	6.2	7.8
HPFT Discharge Temp ChB, Deg R	6.4	8.2	8.1
HPOT Discharge Temp ChA, Deg R	8.9	5.7	7.8
HPOT Discharge Temp ChB, Deg R	9.5	6.5	9.0
HPOT Discharge Temp ChA, Deg R	3.9	6.4	4.9
HPOT Discharge Temp ChB, Deg R	4.7	7.2	5.0
HPOTP IMSL Purge Pr, psia	4.4	7.5	6.8
HPFTP Coolant Liner Pressure, psia	16.8	15.0	17.7
Low MCC Pc, psid			
Command-ChA Avg	22.3	22.3	21.8
Command-ChB Avg	27.9	26.6	27.5
FASCOS			
HPFTP	14.6	14.1	14.3
HPOTP	32.6	31.7	33.5

HPFTP 6113R1 Tip Seal Fretting

- **Issue**
  - Disassembly inspection of 1st stage tip seals revealed localized cracking and spalling on 2 of 6 segments
- **Background**
  - HPFTP 6113R1: 5 starts / 2,564 seconds on tip seals
  - Tip seal condition consistent with earlier cases of missing material and spalling on current scalloped tip seal design
    - No structural or performance anomalies
  - 771 starts / 333,940 seconds on current configuration to date

HPFTP 6113R1 Tip Seal Fretting



Housing Inner Ring / Tip Seal Isometric View

HPFTP 6113R1 Tip Seal Fretting

- **Successful Experience with Tip Seal Spalling**
  - 3 prior occurrences
    - Approximate mass of spalled pieces: 0.01 - 0.03 grams
  - HPFTP 6113R1 spalled pieces
    - Max size: .085L x .020W x .015D, .01 grams
- **Fretting / Spalling determined to be benign**
  - FOD size below safe impact mass threshold of 0.134 grams
    - Worst observed historically = 0.03 grams
  - Large pieces of material self contained
    - Worst case estimate = 0.09 grams
  - Position control of tip seals maintained
    - Only one of 13 lugs per tip seal affected

HPFTP 6113R1 Tip Seal Fretting

- **Rationale for Flight**
  - Reoccurrence of previously accepted condition
    - Prior experience indicates no functional or structural concerns
  - FOD size below safe impact mass threshold
  - Tip seals inspected for blade rub prior to each flight

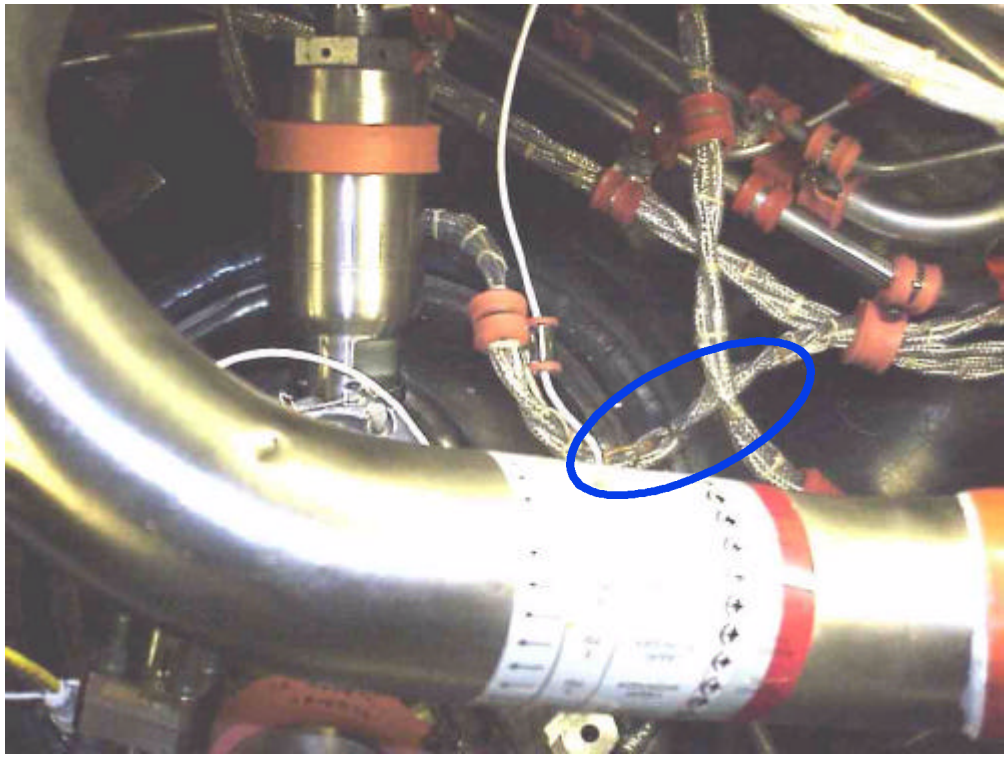
OPB Igniter Harness Damage

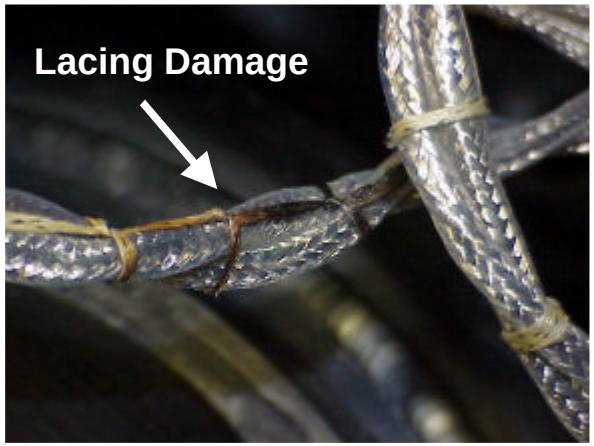
STS-105, E2044

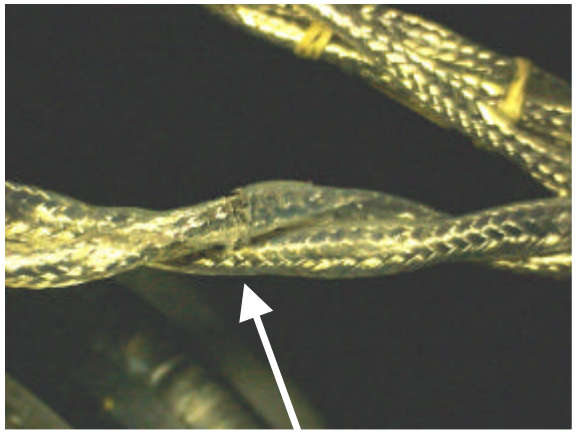
- **Issue**
  - Oxidizer Preburner (OPB) igniter harness damage noted during STS-105 aft compartment closeout walkdown inspections
- **Background**
  - Damage detected on ME-2, E2044 OPB channel A igniter harness (1W13) approximately 16 inches from igniter
    - Visually appears to be localized overheating
      - Light brown / black discoloration of the “lacing cord” (aromatic polyamide flat braid tape)
        - Approximately 6 inches of lacing missing
      - Minimal damage of underlying harness and PFA jacket (teflon)
        - One location with split in jacket
  - Harness History
    - 15 starts / 6121 seconds total
      - 6 starts (5 flights) / 3075 seconds on E2044

OPB Igniter Harness Damage

STS-105, E2044







Teflon Jacket Split

OPB Igniter Harness Damage

STS-105, E2044

- **Investigation / Analysis - In Work**
  - Engine test / flight data review
    - Igniter performance nominal - no anomalies
  - Encapsulation leak check results (1.0 scims allowable)
    - STS-105: .092 scims
    - STS-98: .107 scims
  - Further inspections in work to confirm no other hardware damage
    - None noted as part of walkdown inspection
  - Engine processing records review
    - In work
  - Aft compartment shop work records review
    - In work
  - Harness to be replaced (ECD 8/2/01)
    - Damaged harness will be returned to Canoga for analysis

OPB Igniter Harness Damage

STS-105, E2044

- **Preliminary STS-105 Rationale for Flight**
  - Damaged igniter harness will be replaced (8/2/01)
    - Electrical checks and igniter checkouts will confirm proper functioning
  - Encapsulation leak checks verify integrity of engine joints
    - .092 scims prior to STS-105

Discovery STS-105

Material Review Reassessment

	2052		2044		2045	
	MRs	**PMRB***	**MRs**	**PMRB***	**MRs**	**PMRB***
Powerhead	124	78	86	37	129	81
MCC	22	7	27	7	23	10
Nozzle	76	32	74	31	107	52
Controller	0	0	1	0	0	0
HPFTP	210	98	203	98	226	81
LPFTP	56	20	64	28	58	22
HPOTP/AT	164	53	225	51	134	48
LPOTP	39	10	39	14	43	15
Assembly Ops	145	37	108	37	135	43
Ducts/Interconnects	90	60	78	49	67	37
	926	**395**	**905**	**352**	**922**	**389**

Total PMRB MRs = 1136
Total MRs = 2753

*MRs that would meet today's Rocketdyne PMRB criteria

All dispositions reassessed and found acceptable for flight.

Discovery STS-105

SSME Certification of Flight Readiness

- **Flight Readiness Review CoFR Exception**
  - PR ME2044-0121: E2044 OPB Igniter Harness Damage

Discovery STS-105

SSME Readiness Statement

- **The Discovery Main Engines are in a ready condition for STS-105 pending closure of open work**

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