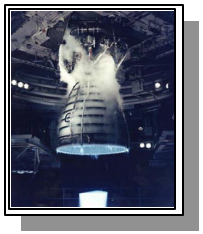
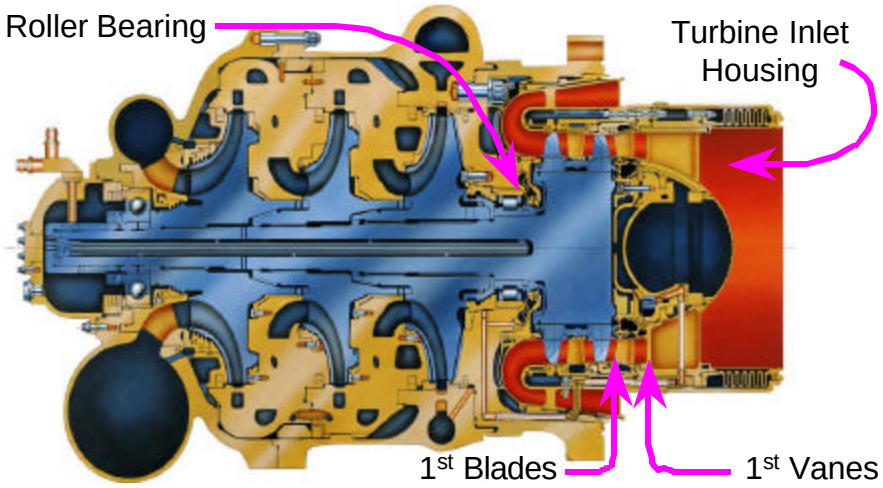
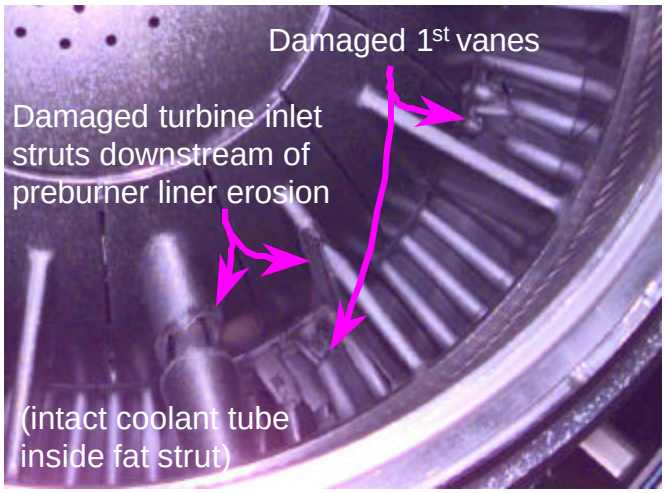


Space Shuttle Main Engine
SSME 0523, 902-772 Incident Investigation

Damage to the HPFTP/AT

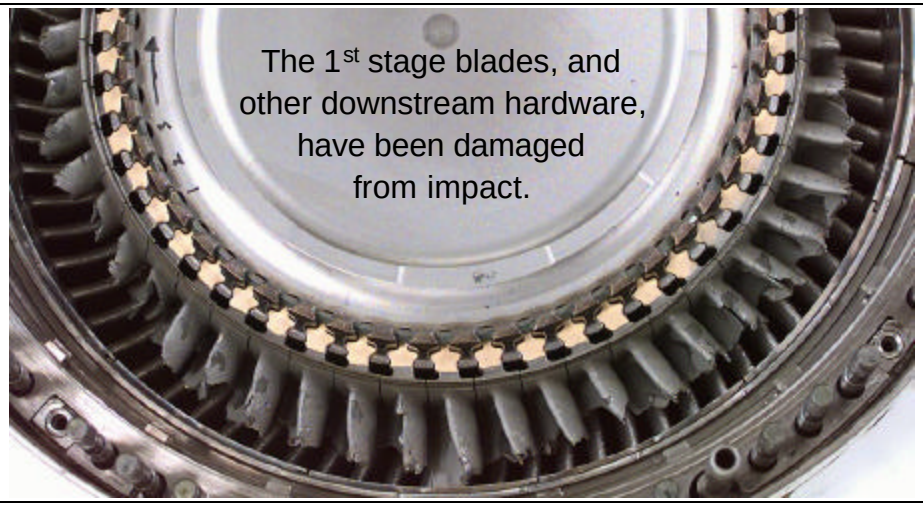
The majority of the damage occurred in the turbine-end. Damage incurred in the turbine downstream of the 1st blades resulted from impact. Pump-end hardware was damaged by rub and the loss of roller bearing support.



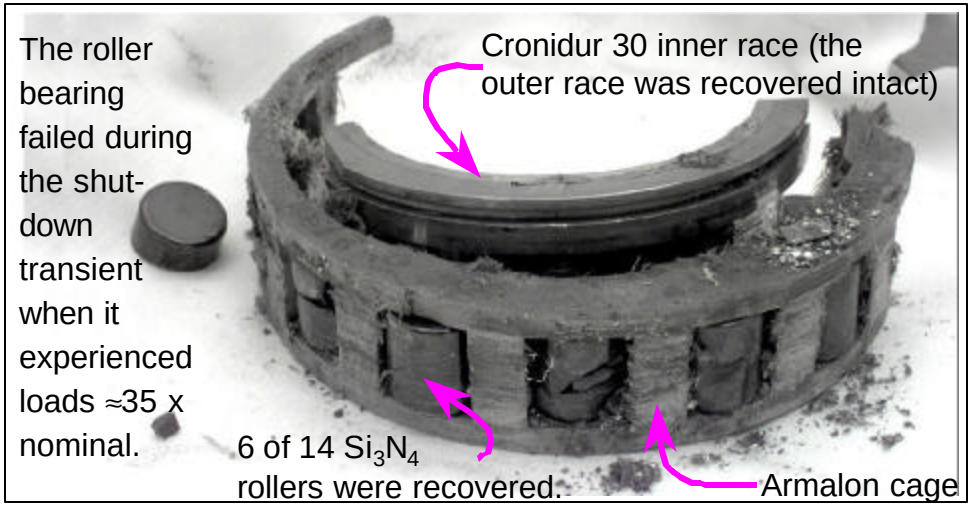


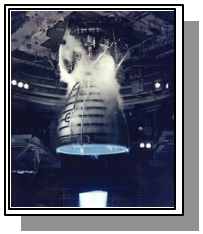
Turbine inlet struts and 1st vanes (stator) were eroded.

The airfoils of a segment of 1st vanes were eroded through, liberating that segment's inner platform to impact the 1st blades.



The roller bearing failed during the shut-down transient when it experienced loads ≈35 x nominal.

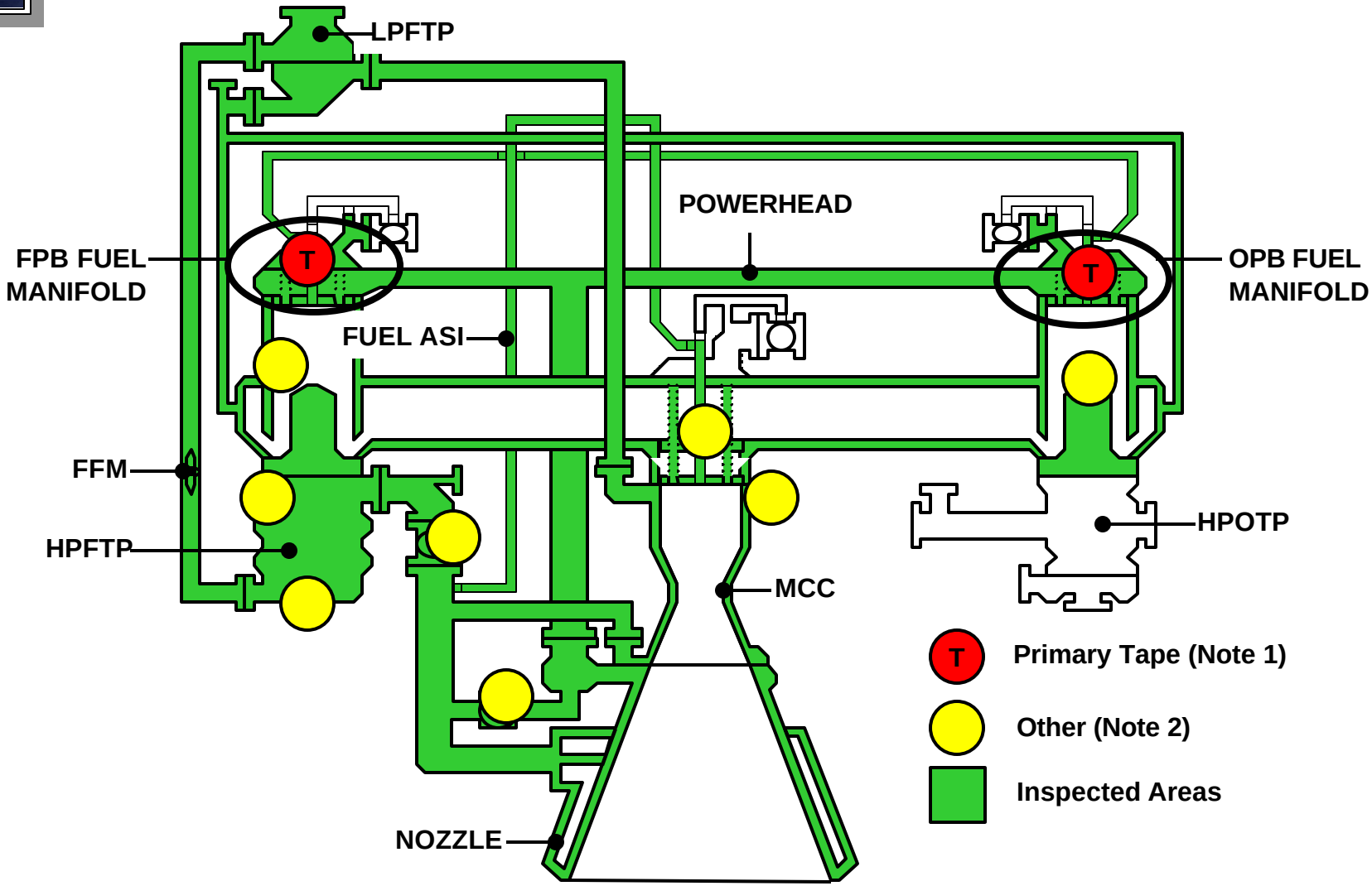




Space Shuttle Main Engine

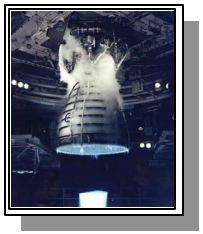
SSME 0523, 902-772 Incident Investigation

ENGINE 0523 FUEL SYSTEM CONTAMINATION POST 902-772



NOTE 1: Total amount of primary tape contamination estimated to be 24 square inches

NOTE 2: Other contamination consists of HPFTP/AT debris generated during the failure and insignificant amounts of various debris normally found during disassembly



Space Shuttle Main Engine

SSME 0523, 902-772 Incident Investigation

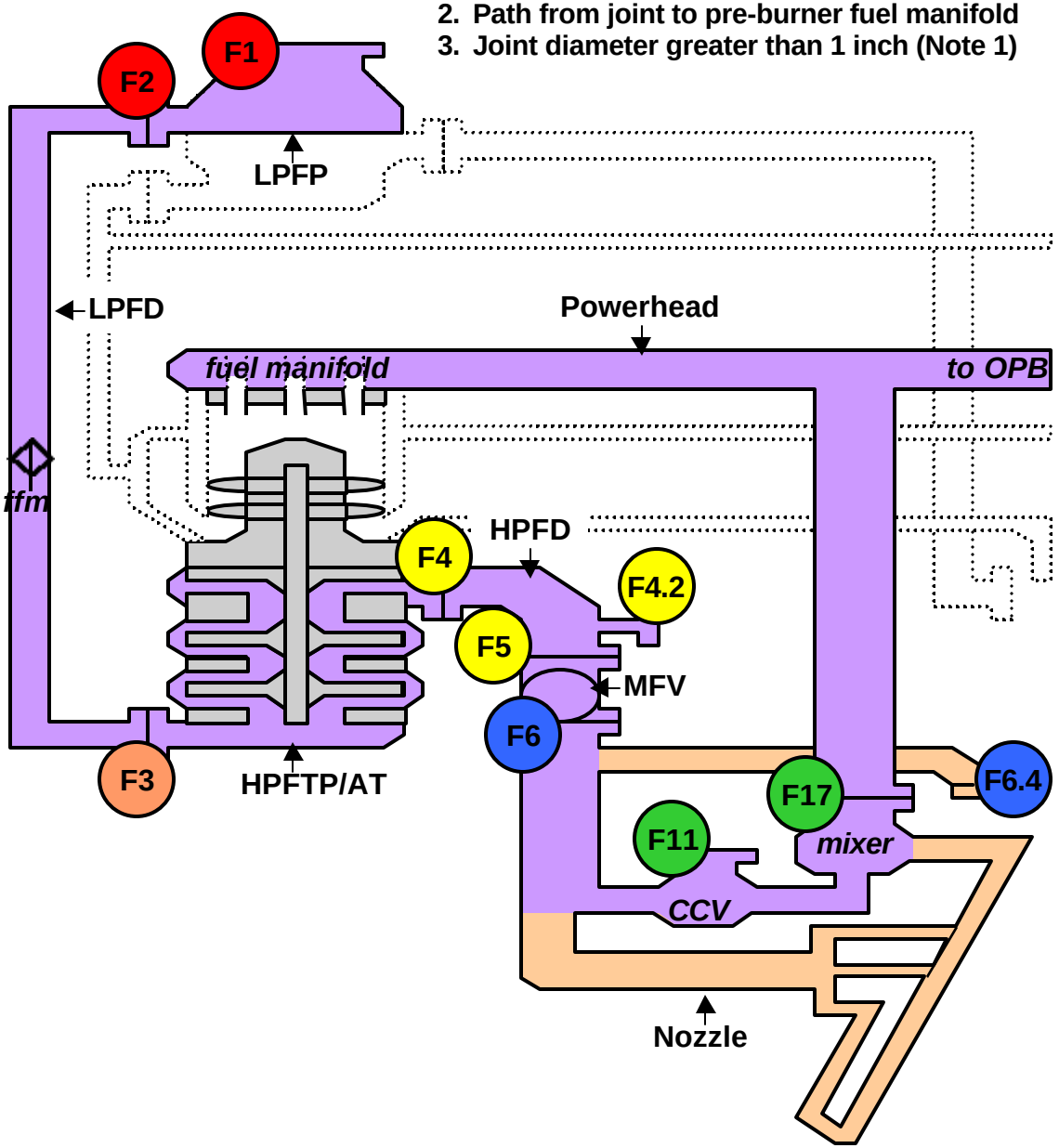
CANDIDATE POINTS OF ENTRY FOR ENGINE 0523 TAPE CONTAMINATION

CRITERIA

1. Joint broken since last hot-fire
2. Path from joint to pre-burner fuel manifold
3. Joint diameter greater than 1 inch (Note 1)

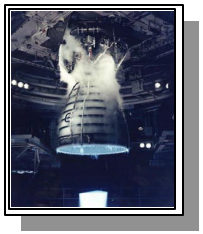
LIKELIHOOD FOR POINTS OF ENTRY

HIGH MEDIUM LOW	Clear Path to Manifolds No MCC/Noz Tape Debris No MCC/Nozzle Tape Debris after Engine Chill (NOTE 2)
LOWER	No HPFP Tape Debris, & No MCC/Nozzle Tape Debris after Engine Chill (NOTE 2)
LOWEST	No FFM Tape Debris, No FFM Detection, No HPFP Tape Debris, & No MCC/Nozzle Tape Debris after Engine Chill (NOTE 2)
PRIMARY PATH TO MANIFOLD SECONDARY PATH to Manifold	



NOTE 1: 24 square inches of tape forms a ball greater than 1" dia.

NOTE 2: Chilled tape is brittle and more likely to contaminate the MCC and Nozzle



Summary of Board Findings

• Most probable failure scenario and Principle finding

- **During the processing and assembly of SSME 0523, Permacel P-670 tape contamination was introduced into the fuel system.**
  - Despite normal inspections, the tape went unnoticed during the remainder of the assembly and pretest operations.
- **At engine start, the tape was forced downstream and came to rest as debris in the fuel manifold of the FPB, causing a localized high mixture ratio in the FPB.**
- **The resulting hot streak impinged on the turbine inlet housing struts and first stage vanes**.
- **A vane segment burned through and the inner section fell into the first stage blades.**
  - This caused rotor imbalance and significant turbine and pump damage.

• Summary of Major Recommendations

- **Verify that all systems are free of foreign object debris prior to hotfire.**
- **Limit the opportunity for contamination introduction by minimizing the use of potential contaminants and using permanent closures on joints where applicable.**
- **Keep joints closed at all times when access is not required to perform work.**
- **Implement an improved method of accountability for loose, non-serialized materials used in SSME processing.**
- **Also, investigate the use of reusable barriers when a contamination barrier is required.**