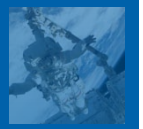
National Aeronautics and Space Administration






Hit the Bricks:

LC-39 Pad A Flame Trench Damage

Leadership ViTS Meeting

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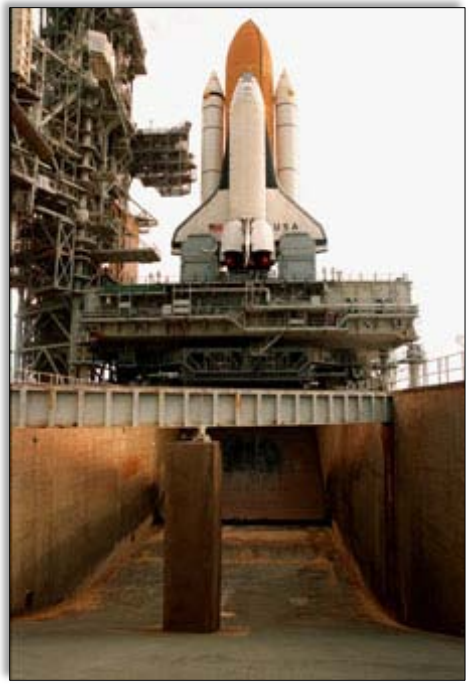
sma.nasa.gov/safety-messages

THE MISHAP

"Flawless" was one description of the May 31, 2008 launch of the Space Shuttle Discovery on mission STS-124. So when the NASA Safing team at Kennedy Space Center set out to inspect Launch Pad 39A following that launch, they were surprised to find the area littered with debris. Powerful exhaust from Discovery's liftoff breached the flame trench wall at the base of the pad. Hot gases had penetrated the trench lining system, blasting over 3,000 refractory bricks into and beyond the trench. Direct damage cost was estimated at 2.5 million dollars.



The flame trench of Pad 39A

Flame Trench

•Channels exhaust away from the orbiter and supporting structures.
•Rests on an 11-foot-deep concrete floor and is contained by 3-foot-thick concrete walls.
•Trench is inspected before and after each space shuttle launch for foreign object debris or visual damage.

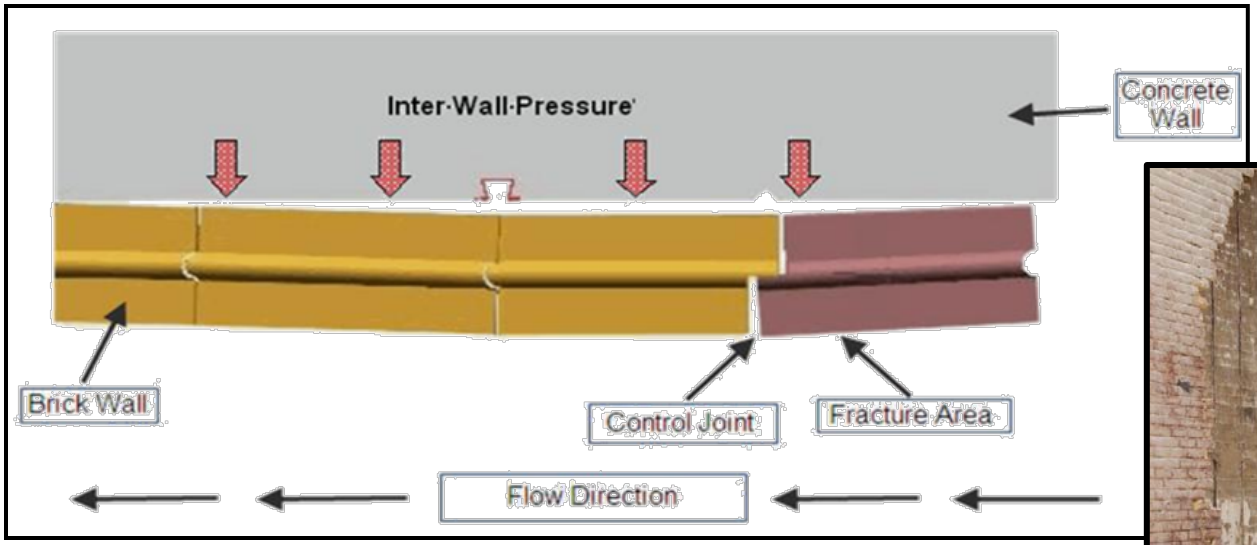
Refractory Brick

•Protects walls of flame trench against extreme temperatures and pressures imposed by the launch.
•Built using an interlocking tongue and groove design.
•Glued together with epoxy and anchored to concrete-embedded steel rails.

Fondu Fyre

•Heat-resistant, spray-on compound was used to repair flame trench wall when loose, missing, or eroded bricks were identified.

WHAT HAPPENED?



Discovery Launch

- Forces from SRB ignition caused a section of the wall that had been repaired with Fondu Fyre to tear away, creating a fracture in the brick lining.
- Hot gas seeped through the fracture and built up between the concrete wall and the refractory bricks.
- The bricks gave way to the pressure of the hot gas and burst away from the concrete at the control joint.
- The interlocking design propagated a cascading effect that blasted the bricks varying distances, some exceeding 1,800 feet.
- The flying bricks, shown by radar to travel up to 680 miles per hour, damaged the opposite wall and a nearby security fence.









PROXIMATE CAUSE

Inspection teams were unable to detect severe carbonation of the epoxy and extensive corrosion in the steel anchors hidden beneath the brick lining. Operators were unaware of the imminent failure in the flame trench wall and cleared the pad for launch. When Space Shuttle Discovery blasted off, dynamic loads from the exhaust liberated thousands of refractory bricks.

UNDERLYING ISSUES

INCOMPLETE APOLLO-TO-SHUTTLE FACILITIES ASSESSMENT

- As a passive system, the flame trench was exempt from a Failure Modes and Effects Analysis.
- Procedures for inspections , maintenance, or repairs to the flame trench were never developed.
- SRBs emitted HCl as a byproduct, so flame trench walls were bathed in corrosive acid with each launch.
- Combined with water from the sound suppression system and salt from the proximity to the ocean, the environment became extremely damp and corrosive.
- Without FMEA (or equivalent), these unique conditions imposed by the hydrochloric acid bath were never considered, and the hazards of the environment were left unmitigated.

UNRECOGNIZED WARNINGS

- In 2003, outside consultants inspected the launch infrastructure and found several severely deteriorated areas of the flame trench walls of Pad 39A.
- Operators did not recognize the deterioration as a warning sign.
- A 2006 petition to repair eroded refractory brick was denied because of limited funding and lack of priority. The repairs would have cost $320,000.

FOR FUTURE NASA MISSIONS

An inspector examines the repaired section of the flame trench wall.

- Comprehensive inspection, maintenance, and repair processes are critical to properly identifying hazards, even in systems that are apparently reliable.

- Aging support facilities can appear sound but still hide cumulative effects of many stressors.

- Facilities and systems designed to support one program must evolve to account for even subtle hazards imposed by new systems.

- After such transitions, environmental conditions and kinetic events combine over time to weaken even the best designed and built systems unless detect-and-correct measures are budgeted throughout the system's life cycle.