Rocket Propulsion Testing at NASA's John C. Stennis Space Center

E-1 Test Stand Mishap

Rocket Test Facility Operators

Working Group

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- Rocket propulsion test facility
  - Test rocket engines and engine components
- Current test program
  - E1: Integrated Powerhead Demonstrator (IPD)
  - E2: Shuttle ice frost panel testing
  - E3: HMTP (hybrid testing)

E1 Test Stand Mishap/Fire

SSC

- What
  - **Fire**
- Where
  - **North side of the E-1 Test stand**
- When
  - **Saturday February 21, 2004, at approximately 10:08 PM**
  - **During structural welding operations to accommodate a new propellant tank**
- Impacts
  - **Four-man crew vacated the area**
  - **Fire Department called to extinguish the fire**
  - **No injuries to personnel**
  - **Minimal damage to test stand electrical wiring**
  - **Schedule impact to repair**

E1 Test Stand Mishap CAUSES

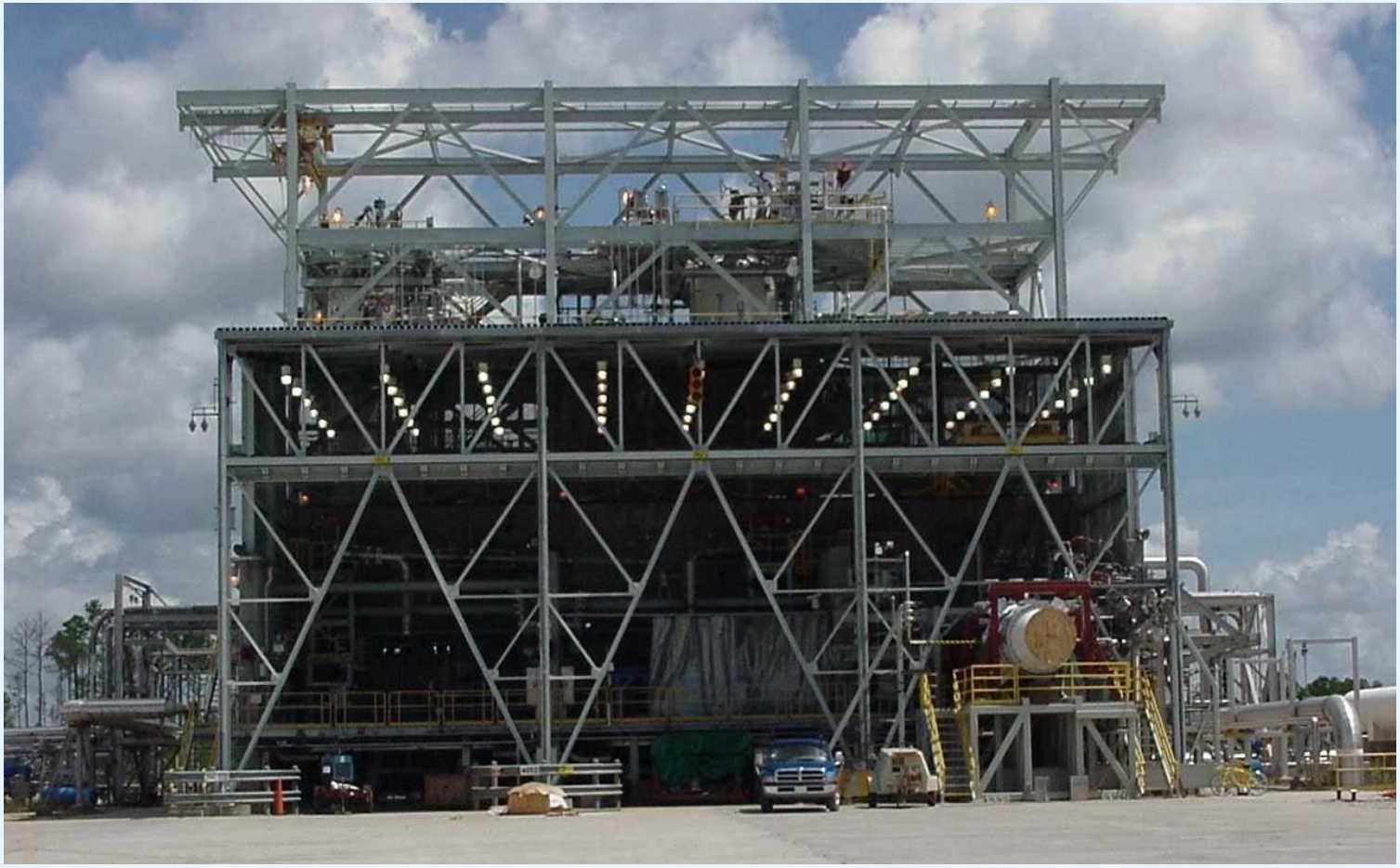
The Mishap Investigation Team (MIT) sought to identify possible proximate causes:

- A damaged welding lead
- Hot welding slag igniting a plastic tarpaulin folded and laying near a cable tray
- Hot slag coming into direct contact with the wiring inside the cable tray
- Sparks igniting a canvas tarp hanging on the outside of the test stand used for wind break
  - * On the night of the fire it was pulled together near the cable tray

E1 Test Stand Mishap CAUSES

- Investigation results (Fire Origin Investigation Team)
  - Hot welding slag igniting a plastic tarpaulin determined to be most likely cause
  - A damaged welding lead
    - Ruled out by welding lead inspections
    - No damage was found
  - Hot slag coming into direct contact with the wiring inside the cable tray
    - MIT could not rule this out
  - Sparks igniting a canvas tarp
    - MIT could not rule this out

E1 Test Stand (Looking North)

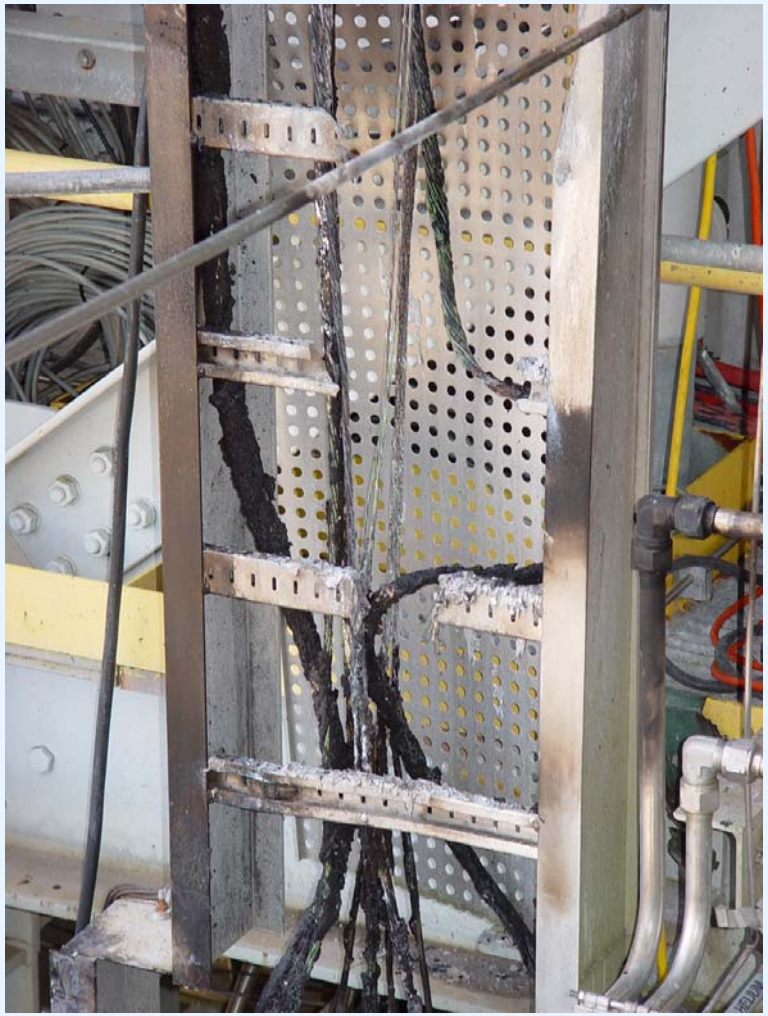


E1 Test Stand (Looking South)

E1 Test Stand Mishap

E1 Test Stand Mishap

E1 Test Stand Mishap



E1 Test Stand Mishap

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Green Tarp used as wind break

E1 Test Stand Mishap
Findings/Recommendations

SSC

Finding # 1: The MIT found that the hot work permit process was not followed. After further investigation it was determined that the utilization of an incomplete hot work permit had become standard practice in the test complex.

Rationale: The hot work permit is issued by the Fire Department and the process requires that the work site be inspected to ensure a safe hot work environment, in this case to perform welding. The Fire Department is supposed to identify the precautions that are to be taken before work begins. In recent years, apparently to meet schedule demands, the Fire Department has sometimes issued hot work permits without identifying precautions and instead of issuing the hot work permit for a specific location has issued the permit for a general area.

Recommendation # 1:
Ensure that all personnel associated with hot work are aware of the hot work permit process and associated requirements. Clearly identify responsibilities including who verifies that precautions have been taken. Ensure a system is in place that will continually verify requirements are being met.

Finding # 2: The welders were not adequately trained in the procedures for conducting "hot" work and they were not aware of MSS's written procedures for welding.

Rationale: During the MIT's site inspection and the subsequent interviews, the MIT found the following shortcomings:

* There was no "fire watch" conducted as required by the MSS welding procedure.
* Adequate fire suppression equipment was not available on the test stand as required by the MSS welding procedures.
* There was no evidence of a site inspection and consequently flammables (tarps, cable tray and wiring, wood, and rags) were not properly protected or removed prior to welding operations.
* Not enough fire protection blankets to protect the area.

Recommendations: Ensure all personnel are trained to the proper procedure and that they are following work procedures.

E1 Test Stand Mishap
Findings/Recommendations

Finding # 3: The fire hydrants, emergency eye wash system, and the fire suppression system in the signal conditioning building associated with the E-1 Test Stand did not have water.

Rationale: A portion of the water system in the E-complex was configured for freeze protection on Jan. 15, 2004. Neither the Fire Department personnel interviewed nor the Chief were aware that the fire fighting water was not available at E-1 although an E-1 work document indicated that the Fire Department had been notified on Jan. 15, 2004.

Recommendation #3a: Implement and enforce a policy prohibiting the indefinite suspension of fire suppression systems without senior NASA management approval. Also, when water is not available, implement a system that ensures safe 'hot' work operation.

Recommendation #3b: Improve the notification process to assure that the Fire Department is aware anytime that a fire suppression system is taken out-of-service and that the Fire Department is provided a date when service will be restored.

Finding # 4: MSS management failed to train supervisory personnel in their roles and responsibilities. MSS management overloaded supervisory personnel with non-supervisory responsibilities.

Rationale: The following management/supervision deficiencies were found:

* MSS supervision is not aware of their responsibilities, is not familiar with work procedures, and lacks the time to visit the work site.
* The onsite MSS safety representative failed to adequately check the conditions at the work site.
* The MIT found that craft supervision personnel are being given non-supervisory project responsibilities which impact their ability to perform supervisory tasks. The role of the supervisor is critical in the implementation of the safe performance of the job. The inability of the supervisor to perform his supervisory role was found to be one of the root causes of the incident.

Recommendation # 4a: Ensure all MSS personnel including supervisory personnel understand their authority, responsibilities, and limits and that they are trained and have adequate time to perform their jobs.

Recommendation # 4b: Analyze workloads of MSS supervisory personnel (and others as appropriate) to ensure adequate time is available to perform safety aspects of their jobs including time to become thoroughly knowledgeable of job requirements and procedures, frequently visit works sites, supervise work crews, review hazardous operations with employees, ensure personnel are properly trained, and be aware of physical and mental health of employees which could affect safe job performance.

Finding # 5: Fire pull boxes located on the upper levels of the test stand when pulled failed to alert the Fire Department of the fire.

Rationale: The fire alarm pull boxes located on the upper levels of the test stand were installed to report hydrogen fires and were consequently wired to the Test Control Room. There appearance, however, caused them to be mistaken for regular fire alarm pull boxes.

Recommendation # 5a: An obvious distinction needs to be made between facility fire alarm system pull boxes and all other pull boxes. Also, evaluate the adequacy of the existing fire alarm system.

Recommendation # 5b: Evaluate the design/design review process to ensure the adequacy of the process, that sufficient time is allocated for review, and that the correct disciplines are involved in the review including human factors.

Finding # 6: Inappropriate tarps were used for a windbreak at the site of the E-1 Test Stand welding operations.

Rationale: The tarp material was analyzed at SSC's Material Analysis Laboratory and offsite at Southwest Research Institute and the material was determined to contain significant amounts of diesel fuel. The tarp material is considered to be highly flammable.

Recommendation # 6: Specifically with respect to the tarps, immediately stop using the tarps in enclosed areas and in locations where hot work operations are taking place.

Finding # 7: NASA personnel accepted the use of an inadequate hot flame permit process.

Rationale: The NASA's PTD management of the work in the "E" Test Complex has for many years emphasized schedule. The workforce looked for shortcuts when being constantly reminded that meeting schedule was the most important factor. This was not being done to purposefully cause safety to be compromised, but the effect was to cause the workforce to put schedule ahead of other considerations.

Recommendation: # 7: Ensure the implementation of all safety related procedures. Any deviations must get adequate review and approval. Further more, all emphasis on schedule must be accompanied with an even greater emphasis on safety. This emphasis on safety must be real. If the contractor is penalized for missing schedule because of safety concerns NASA must be aware of the message being sent.