Frontera Space Emergency Procedure: Long Dwell Contamination

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1 PURPOSE

The purpose of this procedure is to define requirements for the identification, control, passivation, and clearance of **long-dwell contamination** associated with the PTSD (Portable Test Stand) and related test hardware following exposure to hypergolic propellants, oxidizers, or their decomposition products.

This procedure establishes a conservative contamination posture whereby **all wetted components are treated as contaminated by default** until they are thermally passivated and verified inert. The intent is to prevent delayed chemical release, personnel exposure, secondary energetic events, and reactivity associated with trapped or absorbed contaminants.

2 SCOPE

This procedure applies to all PTSD systems, subsystems, and test hardware that have been wetted, exposed, or potentially exposed—either intentionally or unintentionally—to fuel, oxidizer, purge media, or reaction byproducts during normal operations, abnormal events, or failures.

The scope explicitly includes, but is not limited to:

- All test articles, engines, chambers, injectors, valves, and feed components
- All fluid systems, including tanks, lines, fittings, regulators, and manifolds
- All purge and vent systems, including IPA and nitrogen plumbing and flare stack interfaces
- All structural components that may have been splashed, sprayed, vapor-exposed, or soaked during an event
- All fragmented debris, failed hardware, or remnants recovered following fire, uncontrolled energy release (UER), or leak events
- Any component removed from the stand where internal contamination state cannot be positively verified

For the purposes of this procedure, “wetted” includes any component that has had direct liquid contact, vapor exposure, capillary intrusion, adsorption, or internal migration of contaminants, regardless of whether that exposure was part of intended operations.

All components within this scope shall remain classified as contaminated until they have undergone approved passivation via the on-site PTSD bakeout oven and have been verified clear through detector readings returning to 0.0 ppm for applicable species.

This procedure applies during:

- Post-test operations
- Post-incident recovery
- Hardware removal and disposition
- Failure investigation and analysis

No exception to this scope is permitted without explicit approval from the Safety Officer.

3 LONG-DWELL CONTAMINATION CONTROL AND PASSIVATION

Following a fire, uncontrolled energy release (UER), leak, or test failure, all recovered hardware, fragments, and components shall be treated as contaminated by default. No distinction shall be made between visibly damaged parts and intact hardware. Contamination shall be assumed to include residual fuel, oxidizer, and reaction byproducts unless proven otherwise.

All parts shall remain classified as contaminated until they have undergone thermal passivation via the on-site bakeout oven at the PTSD facility and have been verified clear.

Recovered components shall be:

- Collected under approved PPE or SCAPE, as required
- Placed in controlled containment
- Transported to the designated bakeout staging area
- Prohibited from disassembly, cutting, or inspection prior to passivation
- Bakeout shall be performed using the approved on-site bakeout oven under parameters authorized by the Safety Officer. The purpose of bakeout is to:
- Drive off residual volatile contaminants
- Promote dissociation and evaporation of trapped oxidizer species
- Render parts inert prior to handling or analysis
- Parts shall continue to be treated as contaminated throughout and after bakeout until atmospheric verification is complete.

Verification of passivation shall be conducted using calibrated portable detectors appropriate to the chemicals involved. A component shall not be considered cleared until detector readings return to 0.0 ppm for all relevant species (including NO_2 and MMH), with stable readings confirmed.

If detectors do not return to 0.0 ppm following bakeout, the component shall:

- Remain classified as contaminated
- Be re-baked, re-passivated, or
- Be dispositioned for controlled disposal at the discretion of the Safety Officer

No component may be released for inspection, analysis, reuse, or disposal outside controlled processes until contamination clearance is formally granted by the Safety Officer and documented.

Previously wetted components will be labeled with tag or permanent marking that they have been previously wetted and passivated. This marking/ labeling shall remain with the parts until they are destroyed or disposed.

4 PERMANENT PART IDENTIFICATION AND MARKING

All parts, components, and debris subject to this procedure shall be permanently marked to maintain traceability between the hardware and its contamination, wetting, and passivation history.

Permanent marking shall include:

- The part number, and
- A unique identifier or reference number corresponding to the applicable wetting, contamination, and passivation report.

Marking shall be applied in a manner that:

- Is durable and legible for the life of the part,
- Survives bakeout, handling, and storage,
- Does not compromise structural integrity or material compatibility.

Parts shall not be cleared for inspection, analysis, reuse, or disposal until:

- Permanent marking is applied, and
- The marking is documented in the associated wetting and passivation records.

Any part that cannot be permanently marked due to size, geometry, or material constraints shall be placed in a permanently marked container or tag system approved by the Safety Officer, with the same traceability requirements.

This marking requirement ensures positive identification, prevents loss of contamination history, and maintains procedural compliance throughout post-event handling and disposition.

5 DOCUMENTATION

Documentation Requirements

All activities conducted under this procedure shall be formally documented to ensure traceability, accountability, and continuous improvement.

At a minimum, documentation shall include:

- Identification of all hardware, components, and debris classified as contaminated
- Associated part number(s) and unique identifier(s) permanently marked on each item
- Description of the contamination source (event, test, leak, or failure)
- Duration of exposure and suspected contaminants (fuel, oxidizer, byproducts)

- Bakeout oven parameters used for passivation, including temperature, duration, and atmosphere
- Detector types used for verification and recorded readings
- Confirmation that detector readings returned to 0.0 ppm for all applicable species
- Final disposition of hardware (cleared for analysis, reuse, or disposal)
- Safety Officer approval and clearance timestamp

Each documented record shall be traceable to the permanently marked hardware through the corresponding wetting and passivation report.

All records shall be retained as part of the incident or post-test file and shall be made available for internal review, audits, or regulatory inquiry.

6 PROGRAM MAINTENANCE

This document shall be:

- Reviewed annually
- Updated following any contaminate escapes
- Revised when contaminates are updated or changed