Frontera Space Emergency Procedure: Fire and Uncontrolled Energy Release Event

Revision: 01

Frontera Space Document: 000020

12/10/2025

1 PURPOSE

This procedure defines required response actions for fire or uncontrolled energy release (UER) events, including ignition, rapid structural failure, rupture, burst, deflagration, or catastrophic test-article failure occurring at the PTSD stand or associated systems.

The procedure establishes:

- Immediate response to fire or energetic failure
- Hypergolic fire and failure behavior considerations
- Suppression system activation (FireX)
- Emergency stop and stand safing requirements
- Remote assessment and hazard verification
- Cooldown, purge, and passivation requirements
- Personnel protection, accountability, and communications
- Documentation and return-to-operations criteria

These actions ensure personnel safety, prevent escalation, and maintain control of hazardous and energetic systems.

2 SCOPE

This procedure applies to:

- All personnel working in or around the PTSD stand
- All operations involving hypergolic fuels, oxidizers, pressurants, purge systems, and ignition systems
- All tanks, lines, valves, test articles, thrust structures, and flare stacks
- All testing, conditioning, troubleshooting, and recovery activities

Compliance with this procedure and associated training is mandatory.

3 TRIGGERING CONDITIONS

This procedure shall be initiated immediately upon any of the following:

- Visible fire involving the stand or compromised test article
- Unplanned ignition outside intended test sequencing
- Structural rupture, burst, or fragmentation
- Rapid pressure loss consistent with loss of containment
- Loud report, shock, or blast consistent with energetic failure
- Concurrent fire, smoke, or toxic-gas alarm indicating energetic release

Any such event shall be treated as a Fire or Uncontrolled Energy Release Event until proven otherwise.

4 IMMEDIATE CONTROL ROOM ACTIONS

Upon detection of a fire or UER event:

- The Control Room shall announce “Fire or Uncontrolled Energy Release”.
- An emergency stop shall be initiated immediately.
- The stand shall be placed into a fully safed configuration, including:
- Immediate termination of all testing
- De-energization of ignition systems
- Isolation of electrical power as designed
- Closure or venting of fluid systems via fail-safe logic

If operations were active, the stand shall immediately be considered evacuated.

5 ENERGETIC FAILURE & HYPERGOLIC BEHAVIOR CONSIDERATIONS

Fire or UER events involving hypergolic systems may:

- Reignite without external ignition sources
- Continue internal burning after visible flames subside
- Produce highly toxic vapors and decomposition products
- Leave trapped energy or reactive residuals within hardware
- Accordingly:
- Manual firefighting at the stand is prohibited
- All response actions shall be conducted remotely
- Personnel shall assume the presence of toxic and energetic hazards until verified otherwise

6 FIRE SUPPRESSION (FIREX) ACTIVATION

Fire suppression shall be applied remotely using FireX systems.

FireX activation shall follow this hierarchy:

1. Local FireX directed at the affected tank, line, valve, or test article if the event appears localized and containment is likely.
2. Full-area FireX to the stand if:
    - The fire or energetic release involves multiple subsystems,

- Fragmentation or rupture has occurred,
- The source cannot be positively isolated, or
- Local suppression effectiveness is uncertain.

Repeated FireX activation is permitted if required to achieve extinguishment.

7 STAND SAFING AND ISOLATION

Following FireX activation:

- The stand shall remain in a fully safed state
- All ignition sources shall remain inhibited
- Electrical interaction with the stand shall be disabled
- No repressurization, testing, or hardware manipulation is permitted
- The stand shall be treated as energetically unstable until verification is complete.

8 POST-EVENT COOLDOWN REQUIREMENTS AFTER FIRE OR UNCONTROLLED ENERGY RELEASE SUPPRESSION

Following suppression of a fire or uncontrolled energy release (UER) event, a mandatory cooldown period shall be observed prior to any personnel approach or intervention.

The cooldown period is required to ensure thermal stability of the stand and test article, and to allow sufficient time for any residual oxidizer to undergo temperature-dependent dissociation to NO_2 and subsequent evaporation or dispersion. During this period, no personnel are permitted to approach the stand in any PPE posture if both fuel and oxidizer may be present.

If monomethylhydrazine (MMH) and MON-3 (nitrogen tetroxide) are both suspected to have contaminated or become entrapped within a failed test article, plumbing, or structure, the cooldown period shall be no less than 12 hours, at the discretion of the Safety Officer. The Safety Officer may extend this duration based on observed conditions, sensor data, or uncertainty in system state.

Cooldown duration shall account for, at a minimum:

- Thermal mass of tanks, structures, and hardware
- Potential internal burning, smoldering, or localized hot spots
- Continued off-gassing, dissociation, or decomposition of energetic or toxic materials

Throughout the cooldown period, remote thermal monitoring using cameras and installed sensors shall be used to track temperature decay and identify abnormal trends. No physical

approach, inspection, or re-entry is permitted until temperatures have stabilized and cooling trends are confirmed to be monotonic and within acceptable limits.

Authorization to proceed beyond the cooldown phase shall be granted solely by the Safety Officer.

9 CONCURRENT STAND PASSIVATION DURING COOLDOWN

Concurrent with the required cooldown period, the stand shall be passivated to return it to a safe state, provided that fire or uncontrolled energy release has been fully contained and no active combustion is present.

Once fire suppression is complete and a reasonable initial cooldown has been observed, IPA flushing is permitted to remove residual energetic materials from lines and components, subject to Safety Officer approval. IPA flushing shall only be conducted when:

- Active fire or smoldering has been confirmed extinguished,
- Thermal conditions indicate no immediate risk of re-ignition, and
- IPA supply lines and the flare stack are confirmed intact and uninvolved.

If IPA lines, purge plumbing, or the flare stack are suspected to be damaged or contaminated by the event, IPA flushing is prohibited.

Following IPA flushing, the stand shall be passivated using standard techniques to inert tanks, lines, valves, and internal volumes. Passivation shall continue as needed to displace residual oxidizer and fuel vapors and inhibit further chemical reactions.

Throughout cooldown, flushing, and passivation, all actions shall be performed remotely, and safety-system instrumentation shall be continuously monitored to confirm stable conditions and decreasing hazard levels.

No physical approach to the stand is permitted until passivation is complete, system conditions are verified stable, and authorization is granted by the Safety Officer.

10 RELEASE ESTIMATION, DISPERSION, AND NOTIFICATION

In the event of a suspected or confirmed propellant release, an estimated release quantity and dispersion assessment shall be performed to support emergency decision-making. Release characterization and downwind hazard evaluation shall be based on the methodologies and bounding cases defined in the site ALOHA dispersion analysis.

Dispersion assessment shall consider current wind speed and direction and shall assume conservative release conditions until system state is confirmed. Hazard zones shall be treated as directional and downwind-dependent.

If the estimated release or modeled dispersion indicates the potential **for** harmful vapor concentrations extending beyond the property boundary**,** emergency services shall be notified immediately for awareness and coordination.

Notifications shall be made in accordance with EPCRA Tier II and Local Emergency Planning Committee (LEPC) requirements**,** including notification of the appropriate LEPC and Fire Marshal when reportable quantities or off-site impact thresholds are reasonably suspected to be exceeded.

When safety systems are functional and the stand is in a safed state, a SCAPE-suited technician is permitted to walk the inner fence line to verify whether vapors are leaving the property boundary. This activity shall be limited to verification only and shall be conducted using appropriate portable detectors.

11 EMERGENCY NOTIFICATION & PERSONNEL ACCOUNTABILITY

- If the fire is not identified and contained via the FireX system 911 shall be called to notify emergency responders for awareness and standby support.
- Responders shall be informed of:
    - The hazardous materials present
    - Current stand status
    - Nature of the hazard
- The Control Room shall:
    - Confirm personnel safety
    - Verify all personnel are accounted for
    - Confirm stand evacuation status
    - Log personnel status

12 FRAGMENTED DEBRIS COLLECTION AND PASSIVATION

Following completion of emergency notifications and confirmation of personnel accountability, fragmented debris recovery shall be planned and executed in a controlled manner once the stand is verified to be in a safe state.

All debris resulting from a fire or uncontrolled energy release (UER), including fragments of test articles, plumbing, valves, insulation, or structural components, shall be treated as potentially contaminated with fuel, oxidizer, or reaction byproducts until proven otherwise.

Debris collection shall be conducted only after:

- The stand is safed and passivated,
- Atmospheric monitoring confirms no hazardous vapor release, and
- The Safety Officer authorizes entry under the appropriate PPE posture or SCAPE, as required.

Recovered debris shall be:

- Placed into approved containment suitable for contaminated hardware,
- Clearly labeled as post-incident material, and
- Controlled to prevent secondary exposure or reaction.

As part of post-incident stabilization, fragmented debris suspected of containing trapped oxidizer, fuel, or decomposition products shall undergo passivation via controlled bakeout, where applicable. Bakeout shall be performed in an approved oven under defined temperature and duration

Completion of debris collection and passivation activities shall be documented as part of the incident record

13 Safety Officer Role & Emergency Muster

The Safety Officer/Test Director shall:

- Remain continuously on communications
- Report to the designated PPE container / emergency muster location
- Relay real-time status of:
    - Stand condition
    - Alarm readings
    - FireX deployment
    - Personnel accountability

The Safety Officer shall maintain command oversight until the stand is returned to a safe state.

14 Compromised Safety Systems & SCAPE Entry

If stand safety systems are suspected to be compromised, including:

- Loss of sensor reliability
- Loss of control authority

- Inability to confirm valve or system state

Then:

- SCAPE PPE is mandatory for any entry.
- Entry is permitted only to:
- Verify safe state
- Confirm absence of chemical release

Portable gas detectors appropriate to the chemicals present shall be used.

No corrective, repair, or recovery actions are permitted during SCAPE verification entry.

15 Exclusion Zones & Re-Entry Restrictions

- The stand shall remain in an evacuated state during active hazards.
- No personnel may re-enter until:
    - Fire is confirmed extinguished
    - Systems are safed and passivated
    - Monitoring confirms no ongoing chemical release
    - Safety Officer grants clearance

16 Documentation & Reporting

Following stabilization:

- Record:
    - Timeline of the event
    - Smoke/fire source (if identified)
    - FireX deployment actions
    - Stand configuration and purge actions
    - Personnel locations and PPE posture
- A formal incident report shall be completed within **24 hours**.
- Root-cause analysis shall be initiated.
- Corrective actions shall be tracked to closure via QA processes.

17 RETURN-TO-OPERATIONS AUTHORIZATION

Operations may resume only when:

- The stand is confirmed in a safe state
- All hazards are eliminated
- Safety systems are verified operational
- Safety Officer grants clearance
- Test Director issues formal return-to-operations authorization

18 PROGRAM MAINTENANCE

This document shall be:

- Reviewed annually
- Updated following any smoke, fire, or electrical incident
- Revised upon system or facility changes