

E-3 Template Procedures

Important Links

[E3 Dashboard Lucid Chart](#)

E3 Avionics Masterlist: <https://confluence.berkeleyse.org/x/DovgAw>

<https://lucid.app/lucidchart/7354dbc9-be08-41dc-9ee0-bed341d5676e/edit?page=nuHE7GhLR4Zh#>

Notes

(Hotfire) Abort Pressures:

Tank	Auto Gems Pressure	Abort/Relief Valve Pressure	Burst Disk Pressure
Ethane	625	650	700
Nitrous	775	825	900

Fill Pressures:

Tank	Auto Gems Pressure For Fill	Notes	Source
CO2	Flow Pressure - 50psi		
Ethane	Flow Pressure - 50psi		https://www.peacesoftware.de/einigewerte/ethan_e.html
Nitrous	Flow Pressure - 50psi		

Above Tank:

Actuators:

Dashboard Name	Full Name	Function	Type	Notes
GEMS	GEMS Solenoid Vent	Used to slowly drop tank pressures		
E-Vent PBV	Emergency Vent	Used to rapidly drop tank pressure in an abort scenario		
Vent RBV	Slow Vent RBV	Used to drop tank pressures slowly, or maintain tank pressures if GEMS doesn't have enough control authority		<ul style="list-style-type: none">For what RBVs do we definitely want encoder data displayed?Could maybe have status bar on dashboard for actuators display fraction open instead of full only?

Sensors:

Dashboard Name	Full Name	Function	Type	Notes
Tank PT		Measures pressure of propellant tank		
Setpoint		Displays setpoint of tank for cold flow / atomization testing		Only used for water flows / regulated cold flows
Fill Level		Displays volumetric fill level of propellant tank		Uses TC to determine density and load cell + capfill data to determine volumetric fill level
Temperature	<ul style="list-style-type: none">Ethane/Nitrous tank TCs			Used to make sure o-rings stay warm enough <ul style="list-style-type: none">Do we still want RTDs on any fill hardware?

Below Tank

Actuators:

Dashboard Name	Full Name	Function	Type	Notes
Main Valve	<ul style="list-style-type: none">▪ Nitrous Main▪ Ethane Main	Opens up flow of propellants to engine		
Drain RBV	<ul style="list-style-type: none">▪ Nitrous Drain RBV▪ Ethane Drain RBV	Opens up to drain propellants out of tanks and simultaneously close flow to engine		
Fill Line	<ul style="list-style-type: none">▪ Nitrous Fill Line▪ Ethane Fill Line	Opens up propellant fill line allowing propellants to fill tanks		
Fill Line Vent	<ul style="list-style-type: none">▪ Nitrous Fill Line Vent▪ Ethane Fill Line Vent	Vents propellant fill line to allow fill lines to be disconnected from bottles		

Post Blast Shield (Engine, Load Cells, Etc.

Dashboard Name	Full Name	Function	Type	Notes
Injector PT				
Load Cell				
Engine TCs				
Chamber TC?				
Chamber PT?				

Begin flow sequence:

- Nitrous first then ethane?

Aborts:

Manual	<ol style="list-style-type: none">1. Confirm GEMS open2. Confirm Emergency Vents Open3. Confirm Tank RBV Vents Open4. Confirm Drain Valves Open5. Confirm main valves Stay open
NOS Overpressure	<ol style="list-style-type: none">1. Perform procedure outlined in leak check section to raise pressure above 50 PSI2. Confirm GEMS open3. Confirm Emergency Vent Opens4. Confirm Tank Vent Opens5. Confirm Drain Valves stay closed6. Confirm main valves stay open
ETH Overpressure	Same as NOS Overpressure
Engine Overtemp	<ol style="list-style-type: none">1. Confirm GEMS open2. Confirm Emergency Vents Open3. Confirm Tank RBV Vents Open4. Confirm Drain Valves Stay closed5. Confirm main valves Close

LC Underthrust	<ol style="list-style-type: none"> 1. Confirm GEMS open 2. Confirm Emergency Vent Opens 3. Confirm Tank Vent Opens 4. Confirm Drain Valves stay closed 5. Confirm main valves stay open
Igniter No Continuity	
Breakwire No Continuity	<ul style="list-style-type: none"> • Code: • Manually:
Breakwire No Burnt	<ul style="list-style-type: none"> • Code: open GEMS • Manually: dump nitrous/otherwise
No Dashboard Comms	<ul style="list-style-type: none"> ▪ Watchdog - 30s comms dropout (from both dashboards) ▪ Zander Denning ping/status packet ▪ open Emergency Vents + GEMS ▪ manually control things afterwards
Nominal Startup	

1. Test manual abort sequence
 - a. Begin launch sequence
 - b. Press abort button on dashboard
2. Test TC abort sequence
 - a. Begin launch sequence
 - b. Heat gun a TC
3. Test Load Cell abort sequence
 - a. Begin launch sequence
 - b. Step on load cells within 2 seconds
 - c. Step off load cells
4. Test Overpressure abort sequence
 - a. Set overpressure value to 50 PSI
 - b. **Set overpressure value back to values listed in abort table**
5. Test begin flow sequence
 - a. Igniter No Continuity
 - b. Breakwire No Continuity
 - c. Breakwire No Burnt
 - d. Nominal startup - With both keys armed and spare e-match, pull apart breakwire connector after e-match goes off
 - i. Time to make sure that burn duration is as expected and system mode is 1

Before Leaving RFS

1. Following tanks are necessary for each hotfire:

a. Item	QTY	Source
Ethane		
Nitrous		
2000 PSI Nitrogen		

Packing

1. Ratchet strap GSE 'box'
2. Secure vertical system
3. Add additional packing material where necessary
4. Ensure [Hotfire Packing List](#) is complete

System Preparation

1. Assemble engine
2. Ensure minimum 6 assembled igniter fixtures
 - a. Ensure igniter fixtures are properly assembled
 - i. Check continuity of both e-matches: new ematches should have a resistance of ~1 ohm
3. Ensure igniter fixture 1 is attached to burn 1 engine

4. If we have enough igniter fixtures, ensure igniter fixture 2 is attached to burn 2 engine
5. Ensure 11 TC's are attached to burn 1 and burn 2 engine
 - a. 5 around injector (4 around, 1 top plate), 2 along length, 4 around nozzle
6. Ensure avionics box cover is secured well
7. Ensure box wire shield is secured well
8. Secure engine mount bearings
9. Secure bolts on blast shield and attach L-brackets
10. Cushion pressurant tank and c channel
11. Attach engine to system
12. Tape over openings

Checkouts

1. Unload system and tools necessary for checkouts to pad
2. Begin propellant move to pad
 - a. 2 Nitrous
 - b. 1 Ethane
 - c. 1 Nitrogen
3. Remove all packing/transportation material from the system
 - a. Cut zip ties holding down RBV's
 - b. Cut/remove zip ties/Velcro straps on interfering wires
4. Set up avionics box
 - a. 2 AC, 1 Load Cell, 1 TC, 1 PT Board, Cap Fill Comms Board, RTD Board
5. Perform visual inspection of all wiring and sensors and avionics box, report potential issues
 - a. Esp important: Igniter/breakwire
6. Perform visual inspection of propulsion system, report potential issues
7. Set up both ground station laptops and connect to cart via secondary ethernet switch
8. Power on cart and visually inspect avionics boards for LED indicators
9. Confirm all boards are connected to ground station computers
 - a. 2 AC, 1 Load Cell, 1 TC, 1 PT Board, 2 Cap Fill, RTD Board
10. Ensure burn parameters are correct:
 - a. burn duration is correct,
 - b. system mode is 1
11. Perform sensors checkout, note which sensors are broken
 - a. Nitrous Tank PT, Ethane Tank PT, Nitrous Injector PT, Ethane Injector PT
 - b. Nitrous Manifold PT, Nitrous Regen Channel PTs
 - c. 2 Load cells
 - d. 2 Cap fill
 - e. Nitrous tank RTD, Ethane tank RTD, Nitrous Engine RTDs
12. Fix broken sensors
13. Perform actuator checkout, note which actuators are broken
 - a. Connect actuator manifold to 150 psi source.
 - b. Igniter + Igniter Enable Relay
 - c. RBV's:
 - i. AC:
 1. Nitrous Fill, Nitrous Fill Line Vent, Nitrous Main Valve, Nitrous Dump, Nitrous Slow Tank Vent, Nitrous Fast Tank Vent,
 2. Ethane Fill, Ethane Fill Line Vent, Ethane Main Valve, Ethane Dump, Ethane Slow Tank Vent, Ethane Fast Tank Vent,
 - ii. Nitrous Vent Solenoid, Ethane Vent Solenoid
14. Fix broken actuators
15. **[PPE: Safety glasses]** Perform low pressure leak check of system **Perform on Nitrous and Ethane Side of System**
 - a. Connect 2K bottle to leak check QD through regulator (dome pressure line)
 - b. Set dome regulator to fully closed
 - c. Ensure main valve RBV is closed. Ensure dump RBV is closed. Ensure Tank Vent RBV is closed. Ensure Emergency Vent is closed. Ensure Vent Solenoid is Closed
 - d. Open 2k bottle Fully
 - e. Slowly set dome regulator to 50 psi
 - i. Confirm pressurant reading matches dome gauge relatively closely
 - f. Vent fill line using dome regulator
 - g. Wait at least 5 minutes, monitor tank pressure sensor to determine if there are any leaks
 - i. If necessary, use spray bottle to find leaks
 - h. Slowly open Fill Vent RBV to vent system
 - i. Close all open RBV's
 - i. Main Valve RBV, Dump RBV, Tank Vent RBV, Emergency Vent RBV,
16. Check burn parameters
 - a. Ensure setpoints
 - b. Confirm Flow Mode is set accordingly in dashboard config: Set it in main.jsonc (Hotfire = Mode 1) then restart dashboard
17. **Check continuity of breakwire in ignitor fixture that will be used for burn using multimeter, before and after installation into engine!**
18. Test Aborts
 - a. Refer to aborts listed above
19. Cover and protect system
20. Cover and protect GSE 'board'
 - a. Wrap essential equipment
 - b. Tape critical ports
21. Power on streaming cameras and ensure streams are visible
22. Power off system

23. Secure GSE 'board' behind I-beam
 - a. Ensure all RBVs and lines are secure
24. Ensure GoPro SD cards have enough storage room
25. Ensure GoPros, laptops, UPS, and backup batteries are charging

Ground Station Setup

1. Run cables from control room to I-beam, routing towards the back of I-beam to avoid danger zone
 - a. Use 2 spools of Igniter cable
2. Plug in extension cord to outlet & 2 power strips into extension cord
3. Tape power strips onto back of tables
4. Position monitors, connect to power, and connect display cables (display port or HDMI)
5. Plug in and tape down Ground side ethernet switch
6. Plug in ethernet cables to Ground side ethernet switch
7. Connect 300ft ethernet cable to ethernet switch
8. Connect igniter cable to ground station boom box

System Setup **before vertical**

1. Propulsion
 - a. Mount blast shield L-brackets and tighten down bolts
 - b. Position Ethane Bottles and Nitrous Bottles behind I-Beam
 - c. Connect fill lines
 - d. Connect Pneumatic Manifold to 2k Nitrogen
2. Avionics
 - a. Connect ethernet cable coming from Ground Station to GSE 'board'
 - i. Ensure that the cable is out of the blast zone
 - b. Place pad igniter boom box at end of short jumper from system
 - i. Connect to igniter cable coming from Ground Station to GSE 'board'
 - c. Route but don't connect power cable to cart, (plug > UPS > cart power strip)

System Setup

Ensure system is well secured to I-Beam

1. Install load transfer structure, loads cells and engine
 - a. Use burn 1 engine, with attached igniter fixture
2. Install engine electronics
 - a. 11 TC's
 - b. Plug in RTDs, PTs
 - c. Igniter
 - d. Breakwire
3. Connect system wires to GSE
4. Re-connect LOx, Fuel main valves pneumatic tubes
5. Position GoPro cameras and tripods
6. Position streaming cameras and run Ethernet/Power cables to secondary power strip behind cart
7. Ensure all streaming camera ethernet cables are plugged in
8. Clean off GoPro acrylic cover

Checkouts

Complete Checkouts listed above

Sunday Morning Prep

1. Uncover system and GSE 'board'
2. Perform hardware visual inspection
3. Perform avionics visual inspection
 - a. [Hotfire 7 Avionics Overview](#) - connections for reference
4. Perform engine inspection
 - a. 11 TC's well connected
 - b. Igniter wire is connected
 - i. Both e-matches connected
 - c. Breakwire is connected
5. Set pneumatic manifold pressure
6. Full open Nitrous bottles

7. Full open Ethane bottles

Procedures Start

1. Confirm injector PTs mapped correctly
2. Confirm flow duration and flow set points are set correctly
3. Confirm abort pressure is set to 800 PSI for nitrous tank, 650 psi for ethane tank
4. Confirm burst disks are TAPED
5. Close all fill line vents
 - a. Ethane Fill Line Vent
 - b. Nitrous Fill Lin Vent
6. Close Emergency Tank Vent
 - a. Ethane Emergency Tank Vent
 - b. Nitrous Emergency Tank Vent
7. Close Tank Vent Solenoids
 - a. Ethane Tank solenoid
 - b. Nitrous Tank Solenoid
8. Close Main Valves
 - a. Ethane Main Valve
 - b. Nitrous Main Valve
9. Close Dump RBVs
 - a. Ethane Main Valve
 - b. Nitrous Main Valve
10. Close Tank Vents
 - a. Nitrous Tank Vent
 - b. Ethan Tank Vent
11. **Confirm data is being saved to influx**
12. Confirm that firmware commit hash is correct:
 - a. **[FILL IN COMMIT HASH]**: TC thresholds of 150 & 200, all aborts enabled
 - b. **[FILL IN COMMIT HASH]**: TC thresholds of 350 & 400, all aborts enabled
 - i. (If changed on 2nd burn, change back to normal thresholds for 3rd burn)

Propellant Fill

1. **Ensure Ethane Fill Line Vent & Nitrous Fill Line Vent closed**

CO2 Fill

1. **Pad Team**: Confirm that the range is clear, and ready to proceed with fuel fill
 - a. If at RFS, ensure halogen lights are off
2. **Ensure Fuel Tank Vent closed**
3. **[M] Open Ethane Fill RBV valve slowly.**
 - a. Make sure pressure is rising, capfill is going up
 - b. Visually and audibly confirm that ethane vent is venting with binoculars or pad cameras
 - c. Watch for liquid coming out of vent
4. **Close** Ethane Fill RBV

Ethane Fill

1. **Pad Team**: Confirm that the range is clear, and ready to proceed with fuel fill
 - a. If at RFS, ensure halogen lights are off
2. **Ensure Fuel Tank RBV Vent closed**
3. **Ensure Fuel Tank E-Vent closed**
4. **Ensure Fuel Tank GEMS open**
5. **[M] Open Ethane Fill RBV valve slowly.**
 - a. Make sure pressure is rising
 - b. After 2 seconds, close GEMS solenoid
 - c. When pressure in tank reaches fill pressure:
 - i. Stop opening Ethane Fill RBV
 - ii. Bang bang the solenoid vent
 - iii. If pressure reaches 10% above fill pressure, open Tank Vent RBV until pressure drops back down to fill pressure
 - iv. If pressure reaches 20% above fill pressure, open tank E-Vent until pressure drops back down to fill pressure
 - v. If pressure reaches 20% below fill pressure, open fill RBV until pressure rises to fill pressure
 - d. Visually and audibly confirm that ethane vent is venting with binoculars or pad cameras
 - e. Watch for liquid coming out of vent or cap fill and tank mass have stabilized
6. **Close** Ethane Fill RBV

Nitrous Fill

1. **Pad Team**: Confirm that the range is clear, and ready to proceed with nitrous fill
 - a. If at RFS, ensure halogen lights are off
2. **Ensure Nitrous Tank Vent open**
3. **[M] Open Nitrous Fill RBV valve fully and slowly.**

- a. Make sure pressure is rising, capfill is going up
 - b. Visually and audibly confirm that nitrous vent is venting with binoculars or pad cameras
 - c. Watch for liquid coming out of vent
4. **Close** Nitrous Fill RBV

End Fill

1. Ask for ground station to toggle gems, watch for Solenoid cycle:
 - a. Nitrous Solenoid
 - b. **Ethane** Solenoid

Pad Closeout

1. **[M]** Arm pad igniter key

Startup

1. Ensure continuity in igniter, arming valve, main valves, main valve vent, RQD, breakwire
2. **Close Nitrous Tank Solenoid** and **Ethane Tank Solenoid**
3. Wait for pressures to reach nominal pressure
4. Arm dashboard igniter key and **confirm** igniter and breakwire **continuity**
5. Begin countdown!

Recycle

1. **Ensure system safety**
 - a. **Depressurize to 20 psi**
 - b. **Ensure adequate time to cool engine**
 - i. **15 mins or all TC's at 35°C**
2. **Ensure Ethane and Nitrous Fill Line Vents Closed**
3. **Ensure Ethane and Nitrous Fill RBV's Closed**
4. **Approach the system after safing**
5. **Close Ethane Bottle Completely**
6. **Close Nitrous Bottle Completely**
7. **Pad Team:** All personnel leave the pad
8. **Pad Team:** Confirm range is clear
9. **Open Ethane Fill Line Vent fully and slowly**
10. **Open Nitrous Fill Line Vent fully and slowly**
11. Remove engine (remove blast shield wings if necessary during that process)
12. Reattach propellant fill lines, and vent hose to fuel vent
13. Data Analysis
14. Disassemble burn 1 engine to extract parts
15. Camera recycle
 - a. Plug in cameras
 - b. Replace SD cards
16. Hardware visual inspection
17. Avionics visual inspection
18. Install new engine
 - a. TC's
 - b. Igniter
 - c. Breakwire

System Securing

1. Assess data rates coming from all boards
2. **Ensure Ethane and Nitrous Fill Line Vents Closed**
3. **Ensure Ethane and Nitrous Fill RBV's Closed**
4. **Approach the system after safing**
5. **Close Ethane Bottle Completely**
6. **Close Nitrous Bottle Completely**
7. **Pad Team:** All personnel leave the pad
8. **Pad Team:** Confirm range is clear
9. **Open Ethane Fill Line Vent fully and slowly**
10. **Open Nitrous Fill Line Vent fully and slowly**
11. **Open Ethane Solenoid & Nitrous Solenoid**
12. **Open Emergency Vents, Dump RBVS, Tank Vents, Close Main Valves**
13. **Turn off** dashboard igniter arming key
14. Change Dashboard State back to "In Checkout"
15. Go back to top if recycling for another burn
16. Wait for system to be completely vented
17. Power off cart completely

