

Accion Systems Inc.

www.accion-systems.com

529 Main Street, Suite 114 · Boston · MA 02129

Phone 617-500-2563



Accion Systems' TILE Propellant Tank Environmental Testing

From December 20th, 2017 to July 24th, 2018

Document release date: July 25th, 2018

Updated: March 18th, 2019

Accion TILE Propellant Tank Testingⁱ

Order of qualification testing on any test hardware is always 1) humidity, 2) vibration and 3) thermal testingⁱⁱ. Qualification vibration testing is always started immediately following humidity to ensure test hardware is fully saturatedⁱⁱⁱ. All qualification-level vibration and thermal testing is done per NASA-GSFC-700A.

Additionally, each test article is exposed to vacuum (depressurized from ambient pressure) multiple times throughout its test lifecycle and subsequently inspected for leaks.^{iv}

Tests in Table 1 are grouped by hardware designation and are not chronological.

Table 1 List of TILE Propellant Tank Tests from December 20, 2017 to July 24, 2018

| Tests Run | Test Description | Test Objective | Test Levels | Pass/Fail Criteria | Test Completion Date (yyyy/mm/dd) | Hardware Tested (all hardware listed below contained a sublimation barrier) | Results |
|---|--|--|--|--|-----------------------------------|---|--|
| Lifetime Test | Thruster performance test under vacuum | Verify successful tank vacuum pump-down and thruster lifetime ion emission test | 1 microtorr vacuum | -Bi-polar operation? -Propellant leaks? | 2018/02/16 | TILE 50 Qualification Tank SN02 | PASS – successful bi-polar operation, no leaks detected |
| Launch Vibration ^v | 3-axis, random vibration | Verify system can operate nominally after launch vibration | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2017/12/20 | TILE 500 Prototype Tank 02 | PASS – no leaks detected |
| Humidity Exposure Test ^{vi} | Long duration/high humidity exposure | Verify propellant water absorption does NOT cause liquid leaking | Qualification level: 99%, 10 days | Propellant leaks? | 2018/05/23 | TILE 500 Prototype Tank 02 | PASS – no leaks detected |
| Thermal Vacuum Survivable Temperature Cycling | Thermal stress test post-vibration | Verify the system has no workmanship flaws and functions nominally after thermal cycling | Qualification level: -30 C to +90 C, <10 microtorr | Propellant leaks? | 2018/05/29 | TILE 500 Prototype Tank 02 | PASS – no leaks detected |
| Humidity Exposure Test | Long duration/high humidity exposure | Verify propellant water absorption does NOT cause liquid leaking | Qualification level: 99%, 15 days | Propellant leaks? | 2018/06/06 | TILE 500 Qualification Tank SN03 | PASS – no leaks detected |
| Launch Vibration + Depressurization | 3-axis, random vibration while depressurizing per Falcon 9 launch pressure profile | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/06/07 | TILE 500 Qualification Tank SN03 | PASS – no leaks detected |
| Thermal Vacuum Survivable Temperature Cycling | Thermal stress test post-vibration | Verify the system has no workmanship flaws and functions nominally after thermal cycling | Qualification level: -30C to +90 C, <10 microtorr | Propellant leaks? | 2018/06/27 | TILE 500 Qualification Tank SN03 | PASS – no leaks detected |

| Tests Run | Test Description | Test Objective | Test Levels | Pass/Fail Criteria | Test Completion Date (yyyy/mm/dd) | Hardware Tested (all hardware listed below contained a sublimation barrier) | Results |
|---|--|---|---|--------------------|-----------------------------------|---|---------------------------------|
| Humidity Exposure Test | Long duration/high humidity exposure | Verify propellant water absorption does NOT cause liquid leaking | Qualification level: 99%, 36 days | Propellant leaks? | 2018/06/06 | TILE 500 Qualification Tank SN04 | PASS – no leaks detected |
| Launch Vibration + Depressurization | 3-axis, random vibration while depressurizing per Falcon 9 launch pressure profile | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/06/26 | TILE 500 Qualification Tank SN04 | PASS – no leaks detected |
| Humidity Exposure Test | Long duration/high humidity exposure | Verify propellant water absorption does NOT cause liquid leaking | Qualification level: 99%, 96 days | Propellant leaks? | 2018/07/24 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Launch Vibration + Depressurization (rapid depressurizing) | 3-axis, random vibration (worst case) | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/05/03 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Launch Vibration + Depressurization (rapid depressurizing) Run 1 of 4 ^{vii} | Worst case axis, random vibration while rapidly depressurizing | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/05/04 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Launch Vibration + Depressurization (rapid depressurizing) repeat Run 2 of 4 | Worst case axis, random vibration while rapidly depressurizing | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/05/04 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Launch Vibration + Depressurization (rapid depressurizing) repeat Run 3 of 4 | Worst case axis, random vibration while rapidly depressurizing | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/05/04 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Launch Vibration + Depressurization (long duration + rapid depressurizing) repeat Run 4 of 4 | Worst case axis, long duration, random vibration while rapidly depressurizing | Verify system can operate nominally after exposure to vibration during depressurization | NASA-GSFC-700A Qualification level: +20% grms & +100% duration | Propellant leaks? | 2018/05/04 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Launch Vibration + Depressurization (rapid depressurizing) | Worst case axis/orientation, random vibration while rapidly depressurizing | Verify system can operate nominally after exposure to vibration during depressurization | Qualification level: 14.1 grms per NASA-GSFC-700A | Propellant leaks? | 2018/05/29 | TILE 500 Qualification Tank SN05 | PASS – no leaks detected |
| Humidity Exposure Test | Long duration/high humidity exposure | Verify propellant water absorption does NOT cause liquid leaking | Qualification level: 99%, 12+ days | Propellant leaks? | 2018/03/07 thru 2018/06/20 | TILE Qualification Tank SN01 thru SN40 | PASS – no leaks detected |

Accion Systems Inc.

www.accion-systems.com

529 Main Street, Suite 114 · Boston · MA 02129

Phone 617-500-2563



ⁱ Inspection occurs pre and post test; each design is inspected before and after each test both visually and with use of leak detection equipment

ⁱⁱ Deviation from this order of testing is acceptable only if supported by engineering analysis

ⁱⁱⁱ See above (ii)

^{iv} Multiple depressurizations: the test articles are placed inside vacuum chambers and exposed to at least millitorr pressures during a depressurization

^v Test done out of order as developmental test to qualification levels

^{vi} During humidity testing, the test hardware is exposed to high humidity continuously per the levels specified except for mass measurements taken outside the chamber periodically

^{vii} TILE 500 Qualification Tank SN05 was subjected to multiple, harsh (rapid) depressurization profiles and an extended duration vibration test for design verification