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Accion Systems' TILE Propellant Tank Environmental Testing

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

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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	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?	2018/2/16	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?	2018/5/23	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?	2018/5/29	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?	2018/6/6	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?	2018/6/7	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?	2018/6/27	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	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?	2018/6/6	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?	2018/6/26	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?	2018/7/24	TILE 500 Qualification Tank SN05	PASS – no leaks detected
Launch Vibration + Depressurization (rapid depressurizing) Run 1 of 4 ^{vii}	3-axis, random vibration while rapidly depressurizing (worst case)	Verify system can operate nominally after exposure to vibration during depressurization	Qualification level: 14.1 grms per NASA-GSFC-700A	Propellant leaks?	2018/5/4	TILE 500 Qualification Tank SN05	PASS – no leaks detected
Launch Vibration + Depressurization (rapid depressurizing) Run 2 of 4	3-axis, random vibration while rapidly depressurizing (worst case)	Verify system can operate nominally after exposure to vibration during depressurization	Qualification level: 14.1 grms per NASA-GSFC-700A	Propellant leaks?	2018/5/4	TILE 500 Qualification Tank SN05	PASS – no leaks detected
Launch Vibration + Depressurization (rapid depressurizing) Run 3 of 4	3-axis, random vibration while rapidly depressurizing (worst case)	Verify system can operate nominally after exposure to vibration during depressurization	Qualification level: 14.1 grms per NASA-GSFC-700A	Propellant leaks?	2018/5/4	TILE 500 Qualification Tank SN05	PASS – no leaks detected
Launch Vibration + Depressurization (rapid depressurizing) Run 4 of 4	3-axis, random vibration while rapidly depressurizing (worst case)	Verify system can operate nominally after exposure to vibration during depressurization	Qualification level: 14.1 grms per NASA-GSFC-700A	Propellant leaks?	2018/5/4	TILE 500 Qualification Tank SN05	PASS – no leaks detected
Launch Vibration + Depressurization (long duration + rapid depressurizing)	3-axis, long duration, random vibration while rapidly depressurizing (extreme worst case)	Verify system can operate nominally after exposure to vibration during depressurization	NASA-GSFC-700A Qualification level: +20% grms & +100% duration	Propellant leaks?	2018/5/4	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?	2018/3/7 thru 2018/6/20	TILE Qualification Tank SN1 thru SN40	PASS – no leaks detected

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