WILLIAM E. BOEING DEPARTMENT OF
AERONAUTICS & ASTRONAUTICS
College of Engineering

Waterfall Calibration Test Procedure

Version 1.0, 2024-05-03

SPACE Lab Capstone

Date: _____ / _____ / _____
yyyy mm dd

Part Number: _____

Serial Number: _____

Initials: _____, _____, _____, _____

Test Objective

This test will collect the calibration data for with and without the waterfall attached to the pendulum to then later experimentally determine the spring constant of the waterfall system. The determined waterfall spring constant will be used to understand the relationship between the waterfall dynamics compared to the system as a whole, for use in evaluating the accuracy of the test stands collected thrust data.

Equipment Required

Qty	Description	Specs/Calibration	Check
1	Test Stand Assembly	Default Configuration (with flexure set FX1)	

1	Flexure Set (Consists of 8 flexures)	FX1	
1	DawgStar Pulsed Plasma Thruster	As Supplied by SPACE Lab	
1	Oscilloscope	As SUpplied by SPACE Lab	
1	Computer		
1	Bubble Level	Concentric	
1	VC1 (metallic vacuum chamber)	As Supplied by SPACE Lab	

Test Procedure

Full plan: we can reference the main system set up except make sure to note excluding any wires that touch the pendulum (this should just be the waterfall hence the name of the test). From there have them run a calibration procedure and record the displacement and associated force. Then hook up the remaining wires (the waterfall) and run the same calibration with the same weight again. Then because we know the applied force from last time, and we have the displacement we can calculate a new total spring constant. Subtract the known flexure and gravitational spring constants to find the remaining value which is the effective waterfall spring constant.

1 Setup

1.01: Determine flexure sizing in accordance to REF-IFS1.

SET# _____

IF: Currently installed flexures do not satisfy REF-IFS1.

Remove incorrect flexures from test stand assembly per assembly instructions

OK? _____

Install determined flexures onto test stand assembly per assembly instructions

OK? _____

1.02: Loosen central bolts on stand feet such that the rubber feet are able to rotate on their pivots.

OK? _____

1.03: Set test stand assembly into vacuum chamber, while adjusting feet to rotate with the curvature of the chamber.

OK? _____

1.04: Place bubble level onto leveling system radial strut.

OK? _____

1.05: Using bubble level, adjust the test stand until level.

OK? _____

1.06: Tighten central bolts on stand feet to lock the rotation of the feet.

OK? _____

1.07: Place the Dawgstar PPT onto the test stand's thruster mount.

OK? _____

1.08: Connect wiring for IL-1000 in accordance with the test stand wiring diagram.

OK? _____

1.09: Connect wiring for electrostatic comb in accordance with test stand wiring diagram

OK? _____

1.10: Connect wiring for leveling system stepper motor in accordance with test stand wiring diagram

OK? _____

1.11 **Trial 1: DO NOT** Connect wiring for PPT in accordance with test stand wiring diagram

OK? _____

Trial 2: DO Connect wiring for PPT in accordance with test stand wiring diagram

OK? _____

1.12: Place bubble level onto leveling system frame radial strut.

OK? _____

1.13: Power on leveling system stepper motor.

OK? _____

1.14: Operate level system stepper motor using Python code until bubble is centered.

OK? _____

2: Safety:

2.01: Mark all exposed high voltage areas with tape

OK? _____

2.02: Monitor both pumps for nominal operation

OK? _____

3: Power Up

3.01: Power on IL-1000

OK? _____

3.02: Confirm data outflow of IL-1000 on computer

OK? _____

3.03: Power on electrostatic comb

OK? _____

3.04: Confirm command capability of electrostatic comb with Python code

OK? _____

3.05: Power on oscilloscope

OK? _____

3.06: Set grid on oscilloscope to 0.1V increment

OK? _____

3.07: Set trigger on oscilloscope

OK? _____

4: Tests

4.01: Close vacuum chamber door

OK? _____

4.02: Start roughing pump, then turbopump to pump down vacuum chamber (VC1)

OK? _____

4.03: Check that indicated chamber pressure is below 10E-7 Torr

Actual Pressure: _____

4.04: **Trial 1: DO NOT** Power on PPT

OK? _____

Trial 2: DO Power on PPT

OK? _____

4.05: Calibrate stand with known impulse by inputting command to electrostatic fins, measure applied impulse

_____ N*s

4.06: Verify the output trace is reasonable

OK? _____

IF: Multiple output traces are not reasonable Go to 6.0, Shut Down

OK? _____

4.07: Save oscilloscope trace to flash drive under naming convention PptName_TestType_###

OK? _____

4.08: Wait 30 seconds post firing to re-fire to allow time for oscillations to damp out

OK? _____

4.09: Fire thruster by pushing trigger button

OK? _____

4.10: Repeat steps 4.06 - 4.09 as needed for impulse/steady-state measurements

OK? _____

4.11: Calibrate stand with known impulse by inputting command to electrostatic fins

OK? _____

4.12: Verify the output trace is reasonable

OK? _____

5: Post Test

5.01: Confirm all .csv data file contain relevant impulse data

OK? _____

5.02: Confirm all oscilloscope traces are saved to a destination as a .csv file

OK? _____

5.03: Ensure calibration constants at the beginning and end of testing are on the same order of magnitude

OK? _____

5.04: Export as a .csv file for documentation

OK? _____

5.05: Save calibration constant results under naming convention CaliC_End/Begin_##

OK? _____

5.06: Confirm files are saved to a destination

OK? _____

Upon a verification of a successful **Trial 1**, follow Shut Down steps 6.01 - 6.02 then return to Setup step 1.11. Follow the usual procedure for **Trial 2** and upon a successful **Trial 2** proceed to fully complete 6: Shut Down

OK? _____

6: Shut down

6.01: Bring vacuum chamber up to atmospheric pressure and open it

OK? _____

6.02: Open chamber door

OK? _____

6.03: Shut off power from: IL-1000

OK? _____

6.04: Shut off power from electrostatic comb

OK? _____

6.05: Shut off power from leveling system stepper motor

OK? _____

6.06: Shut off power from PPT

OK? _____

6.07: Disconnect wires from test stand assembly

OK? _____

6.08: Loosen central bolts on test stand feet to allow feet to rotate on their pivots

OK? _____

6.09: Remove test stand from vacuum chamber

OK? _____

6.10: Examine vacuum chamber for visible scratching

OK? _____

6:11: Close vacuum chamber

OK? _____

CHANGE LOG

Ver	Date	By	E-mail	Change
1.0	5/3/24	Kai Laslett-Vigil	klaslett@uw.edu	Initial Release