Concordia University
Department of Mechanical Engineering

MANU419 Erosion Rig

Standard Operating Procedure

Supervisor: Dr. Medraj

By:
Billy Marquez
Alfredo Martinez-Iglesias

Concordia university
8/27/2012

Table of Contents

Table of Figures

1. Introduction

This document has been written to serve as a standard operating procedure (SOP) to the Barbour Stockwell Incorporated (BSI) Erosion Rig (ER). It will provide a detailed walkthrough of the proper procedures in order to fully execute a complete test. This SOP was not provided by BSI and will only serve as a temporary operating procedure until BSI can provide the Thermodynamics Material Group (TMG) at Concordia University with an official procedure manual.

This is a working document that may be altered in the future for more optimized operation procedures or any additions to the ER.

2. Sample Specifications

There are three types of samples that can be tested on the ER.

1. High Speed Sample (Shaped like a T)
2. Medium Speed Sample (Shaped like an L)
3. Low Speed Sample Holder with Coupon

Each sample will have a maximum testing speed. The following is a table that will provide the recommended maximum speeds for each sample.

Table 1: Sample Speeds

Sample Description	Maximum Speeds	
	RPM	m/s
High Speed Sample	TBA	TBA
Medium Speed Sample	TBA	TBA
Low Speed Sample Holder with Coupon	14500	366

The location of each sample on the rotor is also a very important aspect. The bolt holes located on both the sample and the rotor can determine this location. The following figures will show how the installation of the samples should look.

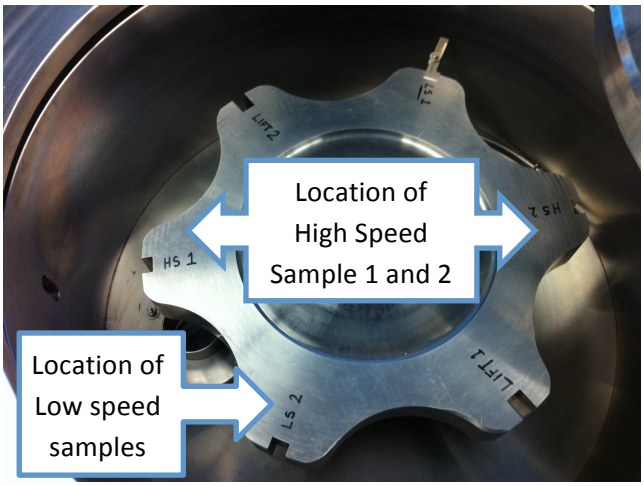

Figure 1: Sample Locations

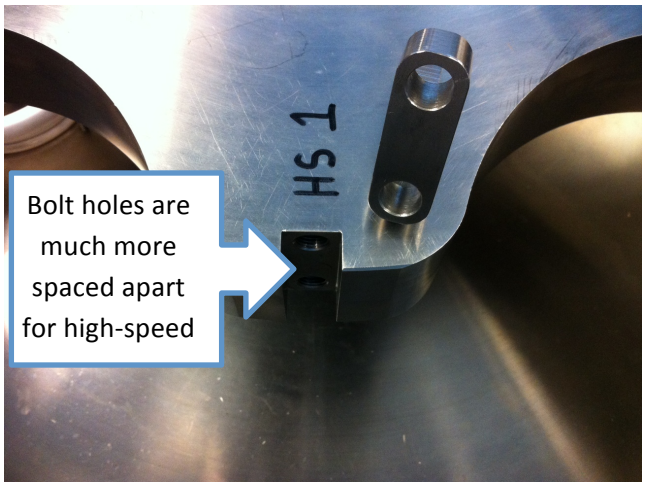

Figure 2: High Speed Sample Location

Figure 3 will demonstrate how a low speed sample assemble would look like when it is complete.

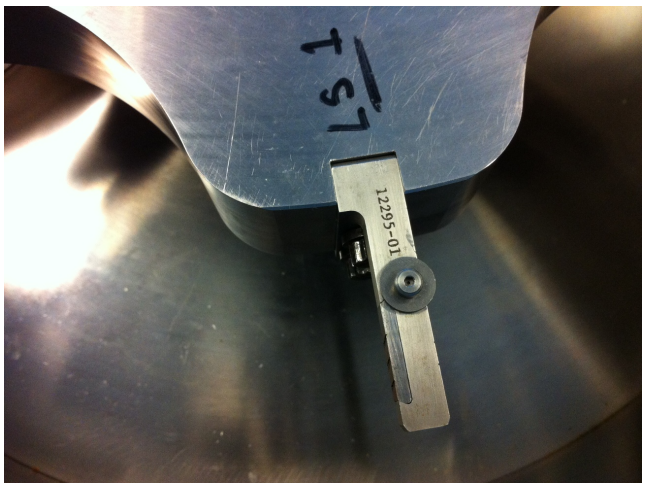

Figure 3: Low Speed Sample Assembly

When securing a sample to the rotor a torque wrench must be used. Each bolt must be torqued to $528\ in \cdot lb$. Figure 4 will demonstrate how this procedure should be done.


Figure 4: Torqueing the sample bolts

3. Setup

Prior to running any test, there must be a pre testing procedure in order to ensure that the samples are setup properly and the software is organized and ready to record. The following steps must be completed prior to any test.

3.1 Sample Setup

1. **Weigh** each pair of samples in order to ensure that they are identical. There can only be a maximum weight difference of no more than $\mathbf{0.1}\boldsymbol{g}$.
2. Install 2 samples and torque the bolts to the required $\mathbf{528}\ \boldsymbol{in \cdot lb}$ as mentioned above.

3. Droplet Generator setup: Adjust parameters to obtain the proper droplet characteristics.

3.1. Set the required flow rate and pressure: This may be achieved by adjusting two valves. Valve 1 is located on the top of the ER and Valve 2 is located next to the water pump. The following figures display the location of the valves.

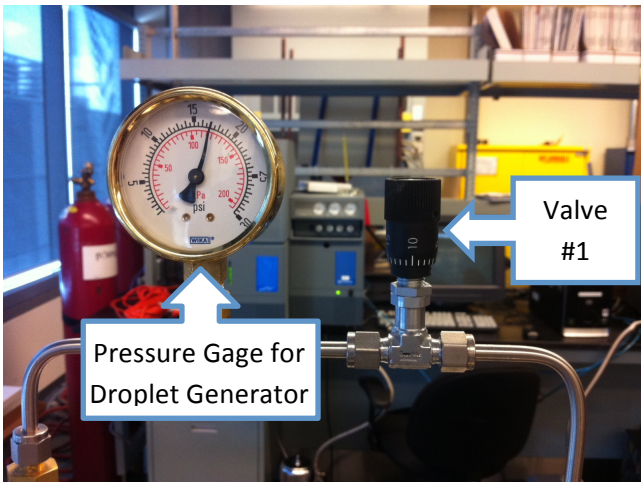

Figure 5: Valve 1 located on top of the ER

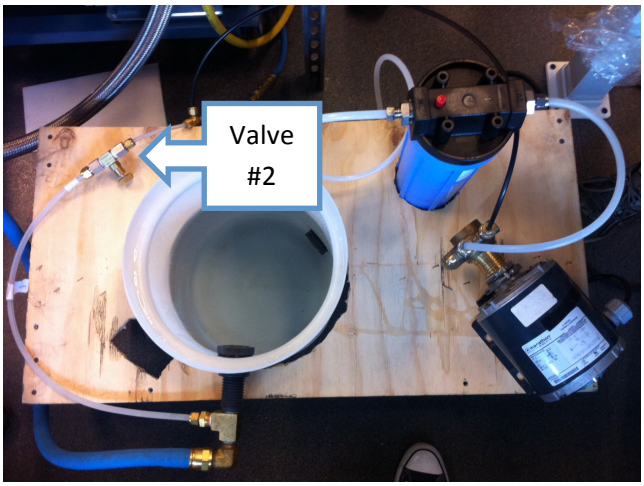

Figure 6: Valve 2 located next to water pump

3.2. Select the Nozzle type. Note the following table will describe the different droplet sizes obtained at different pressures using the different nozzles.

Table 2: Droplet Sizes with different $nozzles$

Nozzle:		$200\mu m$			
Pressure (-psig)	Pressure (mbar)	Droplet Size (mm)			Droplet Count:
		Average	max	min	
14	48	0.38307342	0.55502392	0.22966507	4
13.5	82.5	0.46889952	0.63157895	0.32535885	5
13	117	0.44976077	0.66028708	0.22966507	4

Nozzle:		$400\mu m$			
Pressure (-psig)	Pressure (mbar)	Droplet Size (mm)			Droplet Count:
		Average	max	min	
14	48	0.668175719	0.918859627	0.4784689	4
13.5	82.5	0.752125764	0.985831729	0.473660045	4
13	117	0.637696115	0.756223085	0.526315789	4

Nozzle:		$600\mu m$			
Pressure (-psig)	Pressure (mbar)	Droplet Size (mm)			Droplet Count:
		Average	max	min	
14	48	0.78398579	1.168875138	0.622671712	4

13.5	82.5	0.720893142	0.937799043	0.497607656	3
13	117	0.57913438	0.775651067	0.377111206	5

4. Ensure the water valve #3 is closed: This valve is located above the droplet generator extension as shown in figure 7.

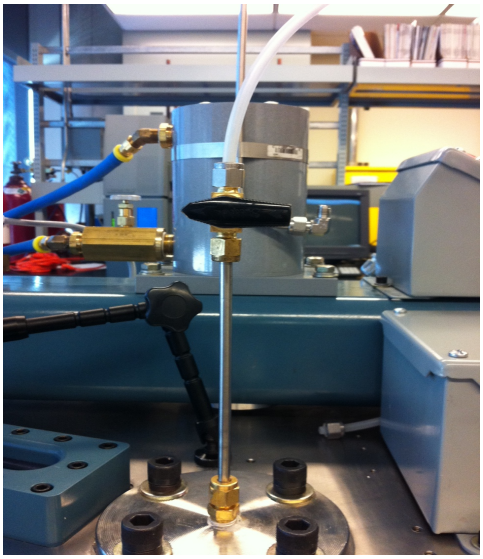

Figure 7: Water Valve #3

5. **WARNING**: Make sure to remove all tools and loose objects from inside the chamber.
6. Close the chamber lid: Slide lid over the opening, place alignment pins. Turn swivel arm located on top of lid and turn the knob on the lift operations panel to the down position as shown in figure 8.

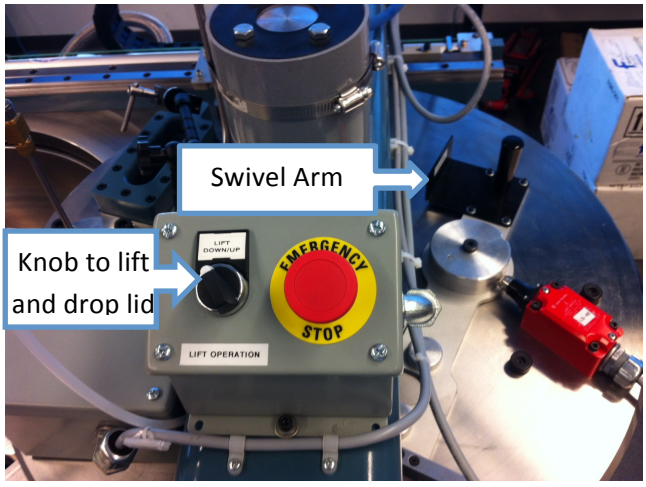

Figure 8: Close Lid

3.2 Software Setup

1. Setup Data Files to store data from each test
   1.1. Open Spin III located on the desktop
   1.2. Go to **File → Enter/Select Data File → File Name** (name the test and place your initials to distinguish each researcher) see figure 9.

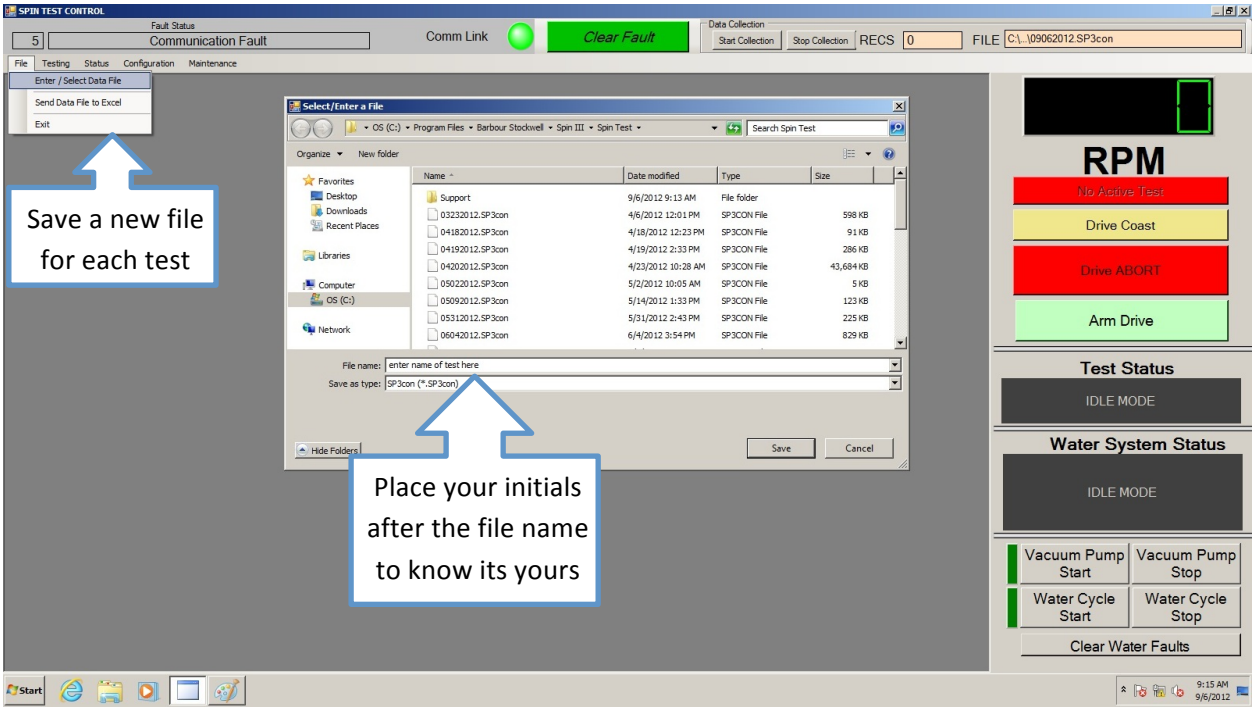

Figure 9: Setup data file

2. Open all workstations in order to configure parameters. Figure 10 displays all required fields.
   2.1. Go to Testing → Constant Speed
   2.2. Go to Status → Analog Display
   2.3. Go to Status → Digital Channels
   2.4. Go to Configuration → Test Parameters

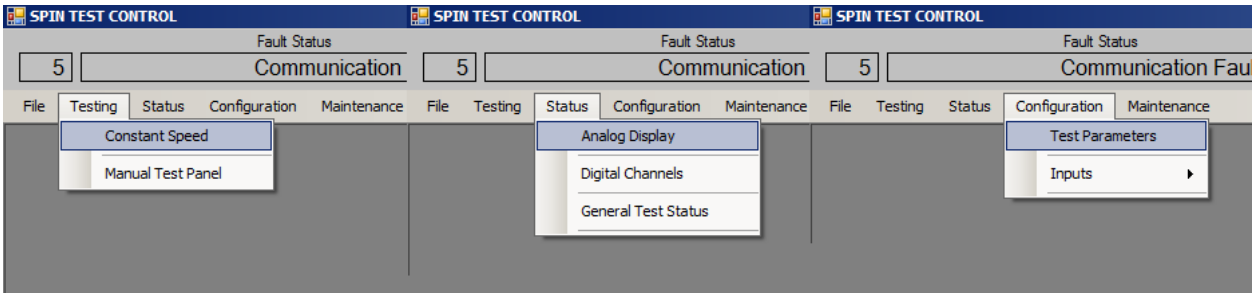

Figure 10: Setup workstations

3. Setup Direction of rotation and Speed Limits. Figure 11 displays a standard test screen.
   3.1. **WARNING**: When standing above the ER if you want the rotor to have a clockwise rotation then you must choose Counter Clockwise rotation in the program.

3.2. In the **Driving Test Parameters** window choose your **Trip Speed, Accel Factor, and Abort Rate**

3.3. In the **Constant Speed Testing** window choose your **Speed Request and Ramp Request** (NOTE: make sure to press **ENTER** once a new speed or ramp is selected, otherwise program will not acknowledge the command)

3.4. **WARNING: TO AVOID RESONANCE MAKE SURE NOT TO STOP BETWEEN THE SPEEDS OF 200 AND 6000 RPM AND ALSO DO NOT STOP BETWEEN 11000 AND 13000 RPM.**

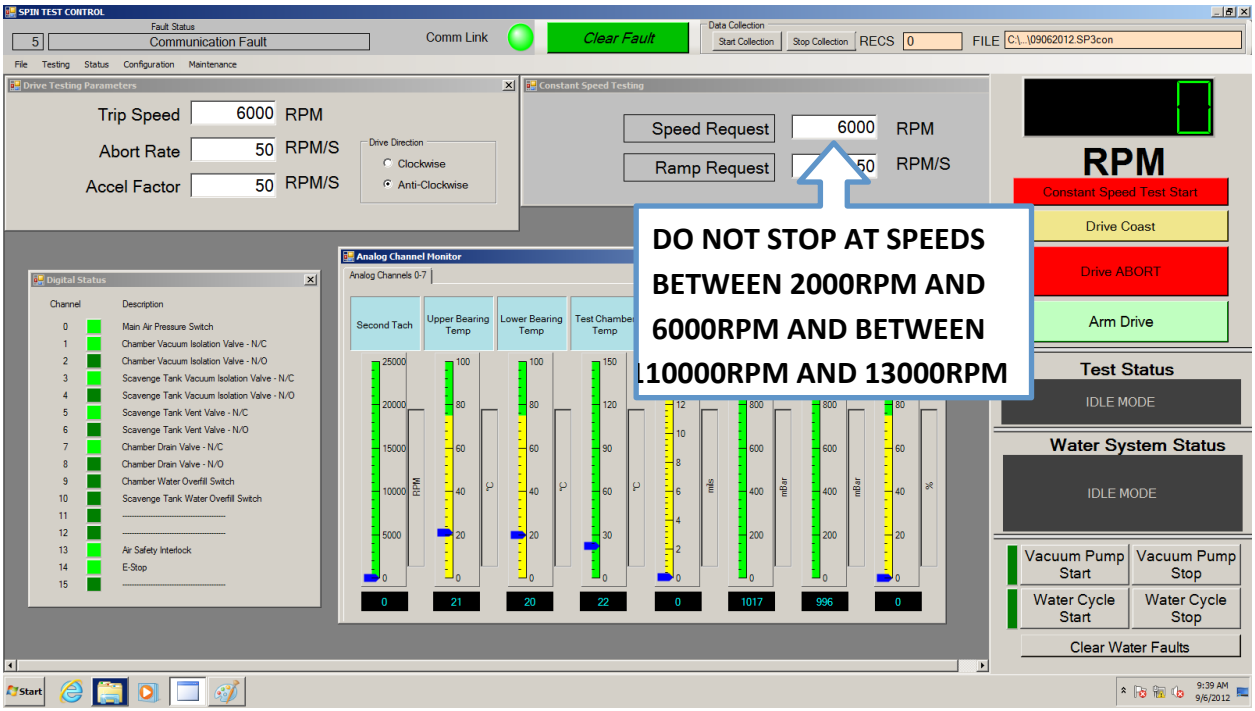

Figure 11: Wokrstations

3.3 Test Run

1. Ensure the Water System/Maintenance window is closed (not displayed on the screen). Figure 12 shows what the water system/maintenance window looks like.

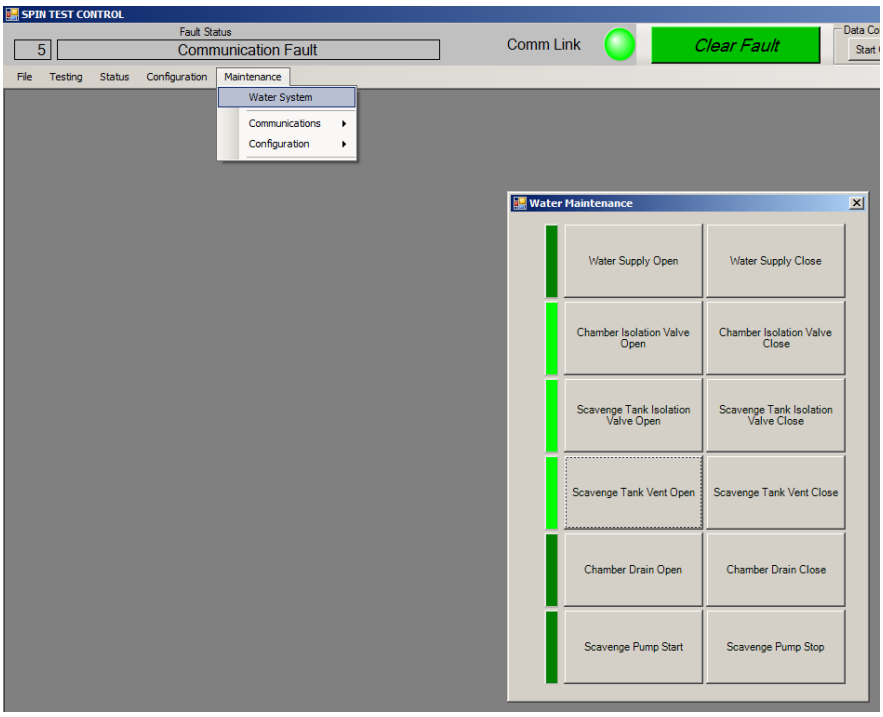

Figure 12: Water System Window

2. Check **"Fault Status"** if a fault is displayed then **"Clear Fault."**
3. Check **"Water System Status"** if a fault is displayed then **"Clear Water Faults."** See figure 13.

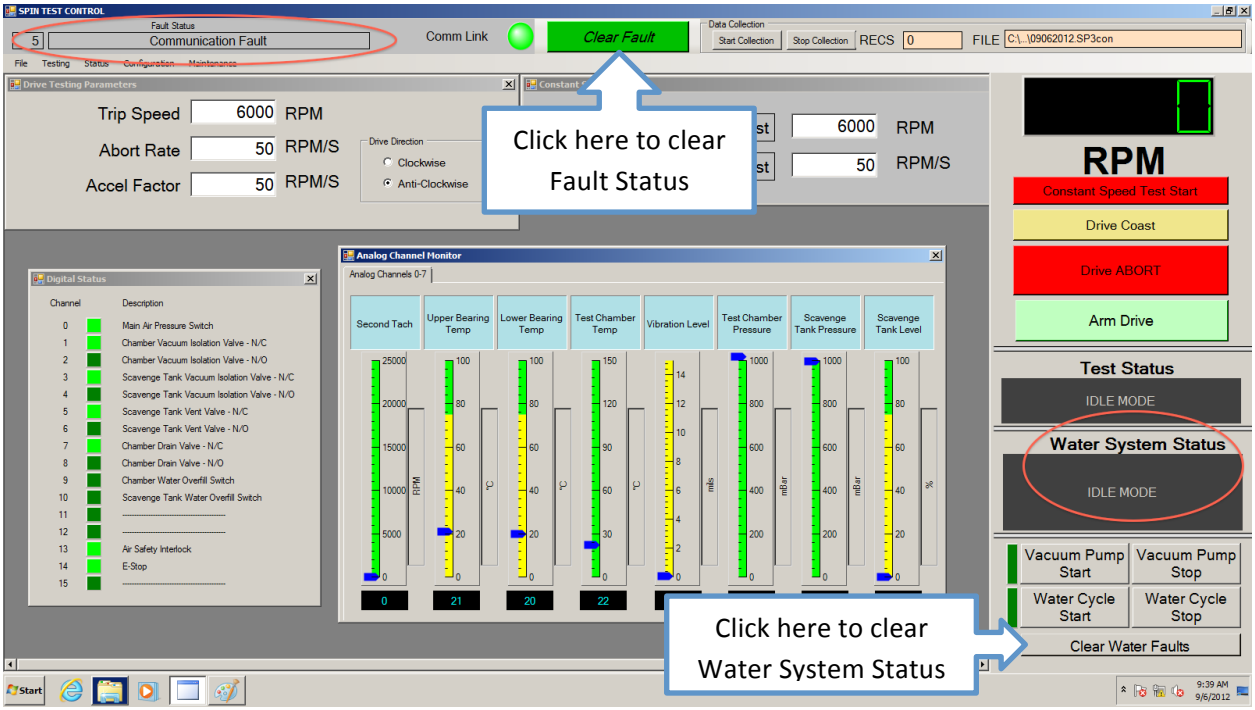

Figure 13: Clear Fault Status

4. Click on **Vacuum Pump Start** located at the bottom right of the screen on the **Test Status Panel.** See figure 13.

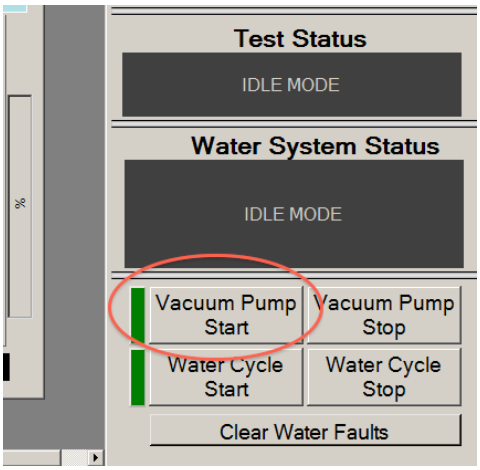

Figure 14: Vacuum Pump Start

4.1 NOTE: wait for Test Chamber Pressure to drop to 25-30 mbar

5. Once Pressure is achieved Click on **"Start Collection"** located at the top of the screen. This will begin recording all data on the file created at the beginning of the software setup.
6. Click on **"Arm Drive."** This will arm the rotor and prepare it for rotations.
7. Click on **"Constant Speed Test Start"** to begin rotation of the rotor.
   7.1. NOTE: When clicking on Constant Speed Test Start you may need to click on it more than once in order to have the rotor continuously rotate.
   7.2. WARNING: If rotor does not spin at all there may be an issue in the compressed air line or in the faulty software. Check to ensure that 100 PSI is on the main line. If rotor still does not rotate (you may hear a slight hissing sound in the air lines) then the software (Spin III) must be shut off followed by shutting down the ER from the Control Station. Restart both the ER and Spin III to begin test once again. Note: You may have to restart both the ER and Spin III more than once.

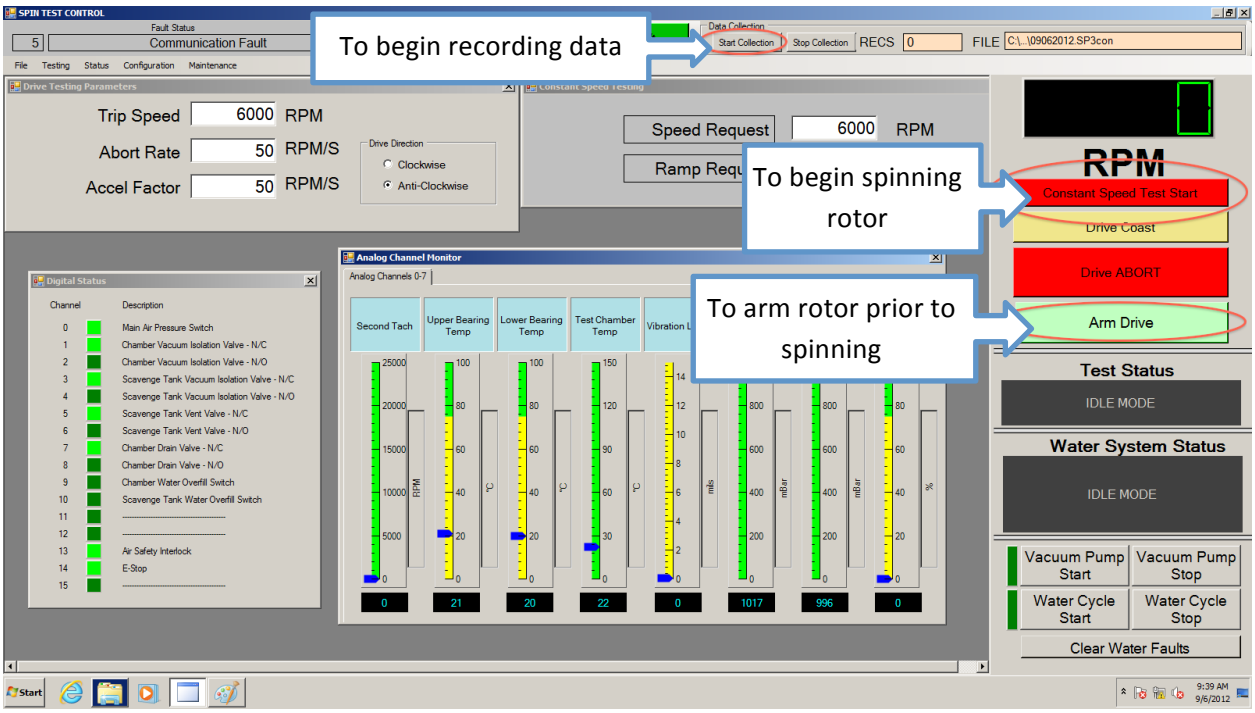

Figure 15: Rotor Startup

8. Turn on Water Pump switch located next to the main compressed air line. See figure 16.

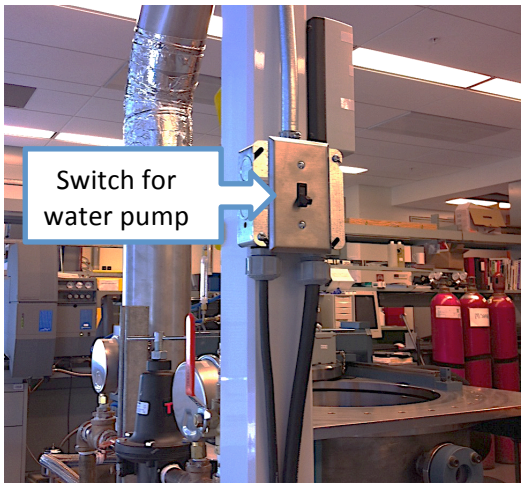

Figure 16: Water Pump Switch for Droplet Generator

9. Once the requested speed is reached click on **"Water Cycle Start."** This will equalize the pressure in both the test chamber and the scavenger tank.

10. Once both the scavenger tank and test chamber are equalized in pressure the drain valve will open automatically. (This will be heard by a click) (Please see User Guide for information on drain valve)

11. Water Valve #3 (see figure 7) can now be opened to begin water erosion test.

11.1. NOTE: Record time when valve #3 is opened. This time should be recorded from Data Collection located on the top right of the screen. This time can then be associated with the pressure drop recorded in the exported data sheet.

11.2. When water erosion experiment is complete simultaneously record the time and turn off water valve #3.

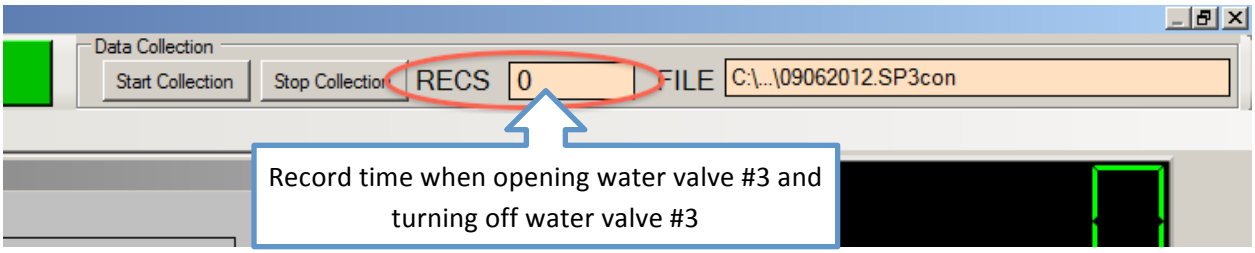

Figure 17: Record Experiment Time

12. Once all data is recorded click on **"Drive Abort"** to begin slowing down and stopping the rotor.

13. Allow RPM to drop to zero: Safety does not permit opening of lid prior to zero.

14. Once rotor comes to a complete stop you can now click on **"Stop Collection"** in order to conclude data collection.

15. Shut off Water Pump Switch for the droplet generator. (See figure 16)

16. Shut down Vacuum Pump: Click on **"Vacuum Pump Stop"** located on the Test Status Panel.

17. Shut down Water Cycle: Click on **"Water Cycle Stop"** located on the Test Status Panel. See figure 18.

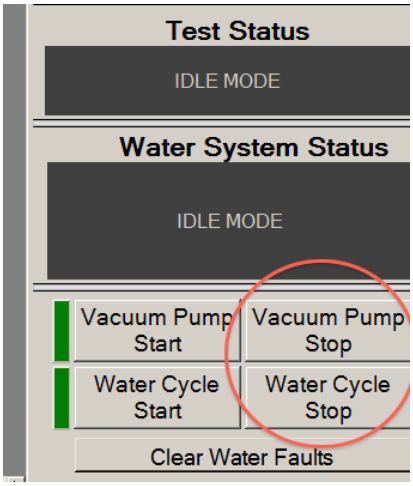

Figure 18: Vacuum shut down

18. Open Water System/Maintenance window: Click on Maintenance → Water System

18.1. Open three Valves: This will allow the entire ER to return to atmosphere pressure. See figure 19.

18.1.1. Chamber Isolation Valve

18.1.2. Scavenge Tank Isolation Valve

18.1.3. Scavenge Tank Vent

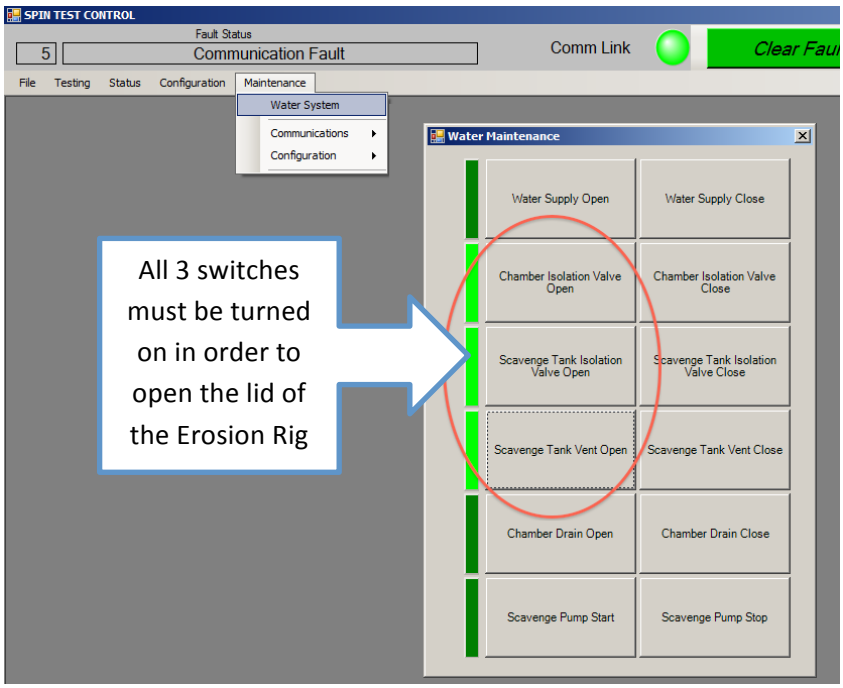

Figure 19: Water System Window

19. Lid may now be opened:

19.1. Turn swivel arm counter clockwise until it stops and hold in place

19.2. Turn knob on "Lift Operation Panel" to up position

19.3. Remove Alignment Pins

19.4. Slide Lid to the right

19.5. Once fully opened place rubber pads under lid and drop the lid on the pads

19.6. **WARNING:** Watch out for fingers. NOTE: If lid is not in down position and rotor is turned manually the lid will slam down automatically.

20. Clean all excess water in the test chamber using the air hose and paper towel.

20.1. To open the test chamber drain go to the water maintenance window and click on **"Chamber Drain Open."** See figure 20.

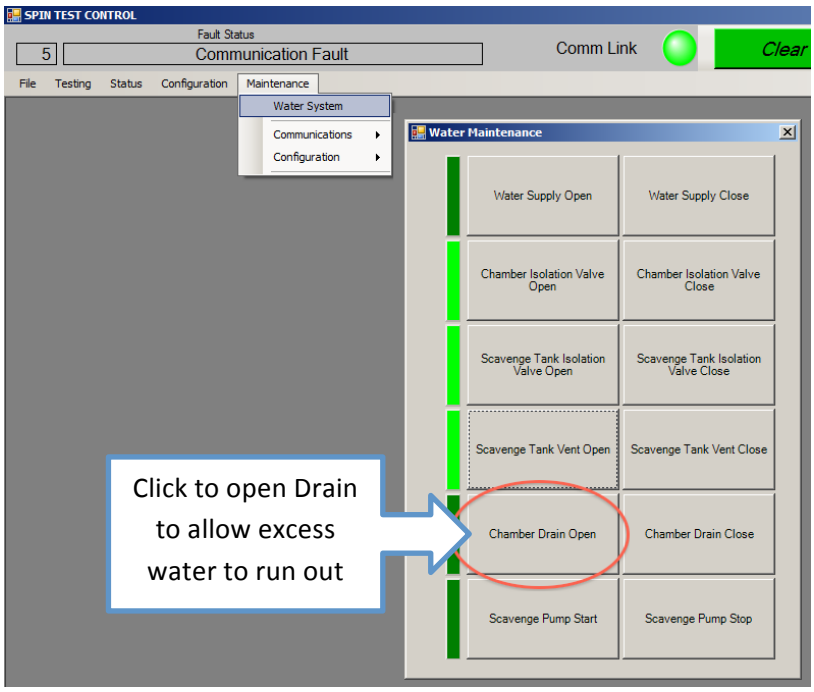

Figure 20: Chamber Drain

21. Samples can now be removed and inspected.

3.4 Empty Out Scavenger Tank

1. Open Water Maintenance window:
   1.1. Click on Maintenance → Water System
   1.2. Click on **"Chamber Drain Open"**

2. Open Scavenger Vent Valve #2 located at the bottom of the scavenger tank. See figure 21

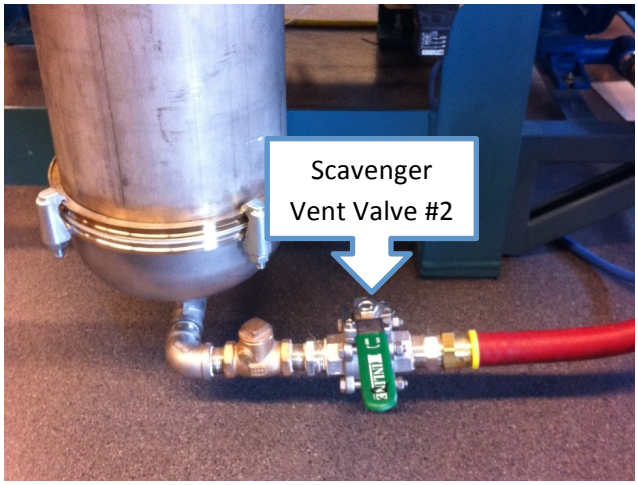

Figure 21: Scavenger Vent Valve #2

3. Click on **“Scavenger Pump Start”** in the Water Maintenance window. See figure 22

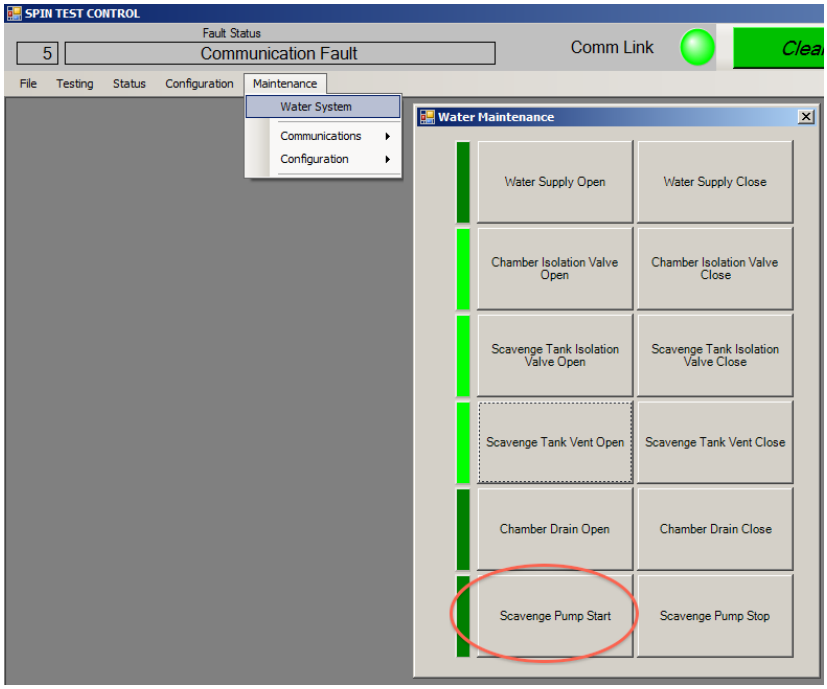

Figure 22: Scavenger Pump Start

4. Slowly open Scavenger Pump Valve #1. NOTE: If you open the valve to fast water will splash everywhere. See figure 23

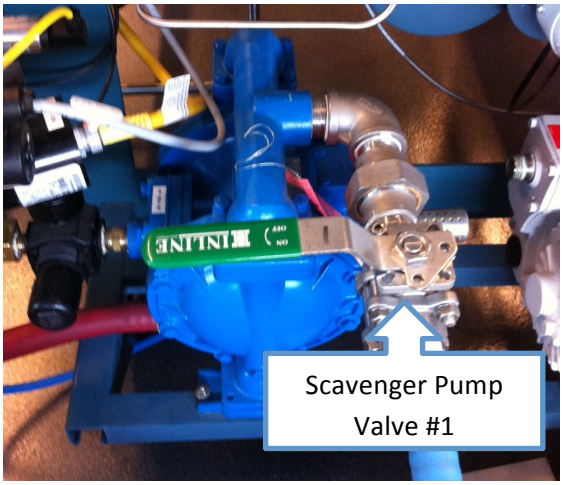

Figure 23: Scavenger Pump Valve #1

5. Once water is completely vented from the scavenger tank click on “Scavenger Pump Stop” in the water maintenance window and turn off both valves #1 and #2.

3.5 End Program

Shut down computer and turn control station off by turning the key to the off position.